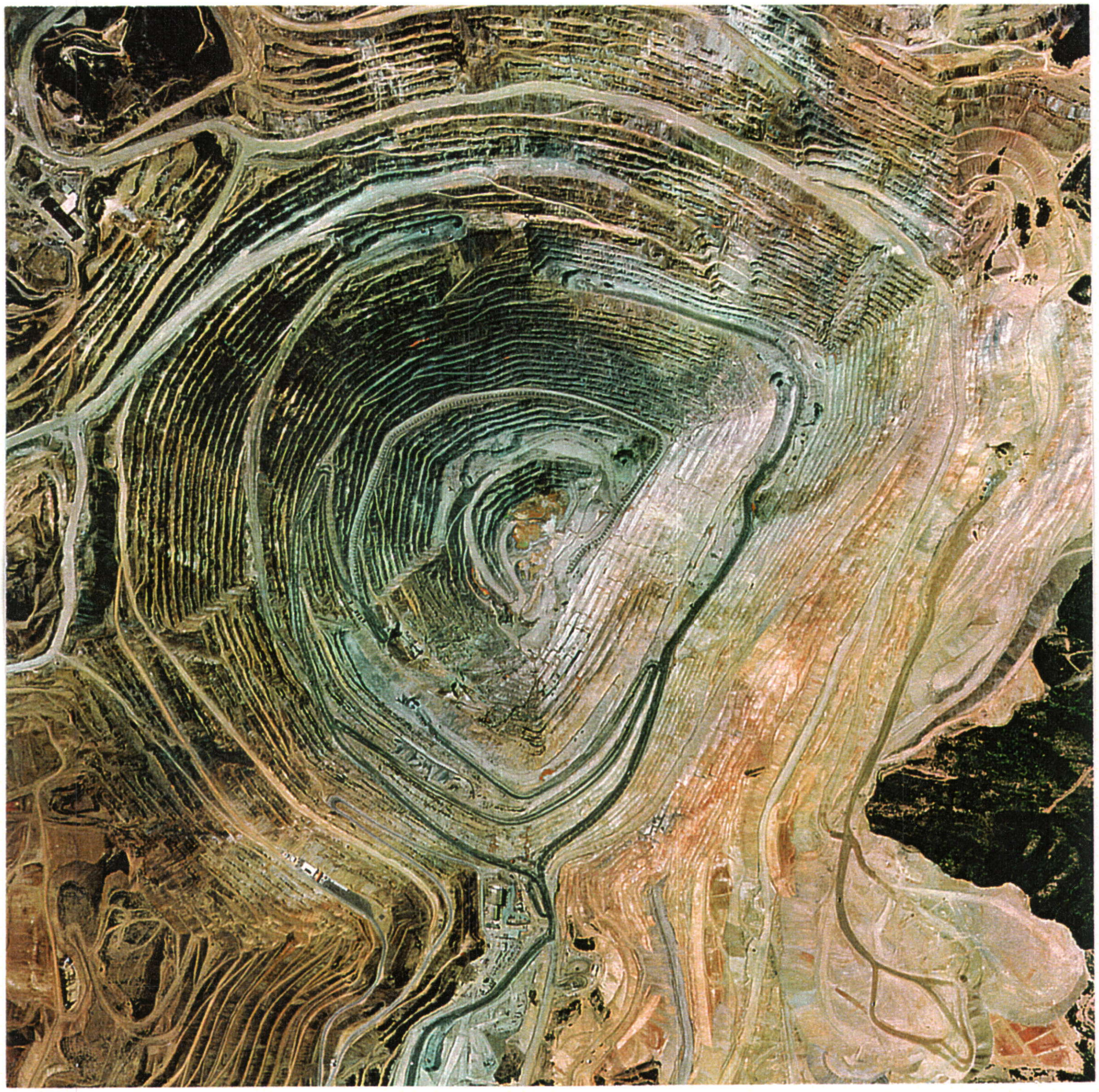
1998 UPDATE OF THE RECLAMATION PLAN FOR THE UTAH DIVISION OF OIL, GAS AND MINING

PERMIT NUMBER M/035/002



KENNECOTT UTAH COPPER CORPORATION

November, 1998

M/035/002

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DIV. OF OIL, GAS & MINING

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Paula H. Doughty
Manager, Environmental Compliance

Kennecott

November 6, 1998

Ms. Mary Ann Wright
Associate Director of Mining
Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
PO Box 145801
Salt Lake City, UT 84114-5801

RE: <u>1998 Update of the Reclamation Plan for Permit # M/035/002</u>

Dear Ms. Wright:

Attached is the 1998 Update of the Reclamation Plan for DOGM Permit Number M/035/002. If you have any questions or comments about this report please call me at 252-3257 or Mr. Rich Borden at 569-6208.

Sincerely,

Paula H. Doughty

Paula H. Doughty
Manager, Environmental Compliance

Attachment

1998 UPDATE OF THE RECLAMATION PLAN

FOR DOGM PERMIT NUMBER M/035/002

Submitted to

Utah Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
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Salt Lake City, Utah 84114-5801

Submitted by

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PO Box 6001
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1.0 INTRODUCTION

This report is intended to provide the Utah Division of Oil, Gas and Mining (DOGM) with an update to the Reclamation Plan for mining-related disturbance within the boundaries of Permit Number M/035/002. Kennecott Utah Copper Corporation (KUCC) submitted the original Mining and Reclamation Plan to DOGM in 1976. It was incorporated into the final Mined Land Reclamation Contract signed on September 28, 1978. Reclamation bonding was waived in lieu of a personal guarantee on the part of KUCC.

The original reclamation plan is still generally valid for KUCC's existing operations and consistent with future reclamation plans. However, the original plan could not be very specific about future reclamation options because of the long life expectancy of the mining operation. These same planning difficulties exist in 1998 because the mine is expected to be in operation for at least another 18 years and perhaps for as many as 50 years. Likely future changes in operations, regulations and technology will require an overly specific plan produced today to be significantly modified in the future.

This report proposes tentative reclamation actions and attempts to establish a preliminary decision-making framework for selecting optimum reclamation actions in the future. To aid in this process, this report also identifies information that is not currently available but that will be needed to make rational reclamation decisions in the future.

1.1 PERMIT NUMBER M/035/002 1976 RECLAMATION PLAN

A copy of the 1976 Mining and Reclamation Plan is attached in Appendix A. The plan divided the permit area into seven operational land use categories and specified maximum areas that could be disturbed within each category: 1) Mine - 3100 acres, 2) Mine Waste Disposal - 8000 acres, 3) Excess Mine Water Disposal - 2700 acres, 4) Ore Transfer - Mine to Process - 400 acres, 5) Ore Processing Facilities - 1800 acres, 6) Tailings Disposal - 6000 acres, and 7) Excess Process Water Disposal - 1000 acres. For each land use category, the plan described the physical setting in 1976 and the land use and vegetation that was present before mining began. It also presented potential post-mining land uses and general reclamation strategies.

1.2 SUBSEQUENT RECLAMATION PLANS

A series of new reclamation plans have been submitted to DOGM since 1976 for new construction projects or land uses that deviate significantly from the original 1978 Permit. A new DOGM permit number was issued for each of these projects and bonding was required. These new permits include the Fourth Line/Copperton Concentrator, Pine Canyon, and the North Impoundment Expansion. None of these new permit areas is discussed in detail in this report because they each have their own detailed reclamation plans. Several additional reclamation plans relating to dust emissions and groundwater quality protection for the existing tailings impoundment have also been submitted to various State agencies.

1.2.1 Copperton Concentrator/Fourth Line Expansion Reclamation Plan

A reclamation plan for the Copperton Concentrator, ore conveyor and tailings pipeline corridor was initially submitted to DOGM in April, 1986. Amended plans were subsequently submitted for the addition of the Molybdenum Plant and for a fourth mill line. These plans describe building demolition and reclamation activities and costs for the ore conveyor and Copperton Concentrator. Total bonding for these facilities is currently $10,429,000. The tailings pipeline corridor was exempted from bonding because of plans to use the pipelines for post-mining water management. These facilities are all managed under DOGM Permit Number M/035/011.

1.2.2 Tailings Pond Reclamation Plans

Several reclamation plans have been submitted for the existing tailings impoundment and for the North Impoundment expansion. The Tailings Pond Final Reclamation Plan was submitted to the Utah Air Conservation Committee and DOGM in July 1988. The plan focused on revegetation strategies and techniques for dust control on the impoundment. It assumed that the existing impoundment would be in operation for another 30 to 35 years, but this plan became obsolete when the North Impoundment expansion was initiated. The initial notice of intent for the North Impoundment expansion was submitted in 1994 and contained a detailed reclamation plan for the new impoundment. Permit number M/035/015 with a bond of $17,485,000 was issued for the North Impoundment in February, 1996. Two reclamation plans have been submitted to State agencies that describe closure and reclamation of the existing impoundment. The Tailings Modernization Fugitive Dust Abatement Program, submitted to the Utah Division of Air Quality in 1994, contains a detailed revegetation plan for the surface of the existing impoundment. The Final Closure Plan for Groundwater Issues, submitted to the Utah Division of Water Quality in 1997, describes how surface and groundwater will be managed on the existing impoundment at closure. These plans are attached in Appendices B and C.

1.2.3 Pine Canyon Reclamation Plan

A reclamation plan for the Pine Canyon Mine and Mill Site was submitted in 1988. The plan was approved and has largely been implemented. Total bonding for Permit M/045/004 is $82,400 for reclamation of the few remaining structures and disturbed acres in the canyon.

1.3 OTHER PERMITS AND LAWS GOVERNING RECLAMATION AND POST-CLOSURE LAND USE

KUCC will have to comply with permits and laws governing surface water, groundwater, air emissions, hazardous wastes and soil contamination both during and after closure. Many of these laws and permits will influence the extent and character of reclamation that takes place at closure.

1.3.1 National Historical Site Registry for Bingham Pit

The Bingham Canyon Mine has been designated as a National Historic Site. This designation may affect the scope and extent of post-closure and reclamation activities that can be conducted at the site. Compliance with National Historic Site requirements will be necessary.

1.3.2 Groundwater Discharge Permits

Existing or pending groundwater discharge permits for the mine, waste rock disposal areas and tailings disposal areas will probably have to be maintained at closure. These permits are managed by the Utah Division of Water Quality (DWQ) and require groundwater quality monitoring, reporting and corrective actions if an out of compliance situation exists. Post-closure permits will probably also specify long-term inspection, performance and maintenance criteria for water collection and containment systems.

1.3.3 UPDES Permit

The DWQ will also manage the UPDES permit for surface water discharges off the property after closure. The UPDES permit will specify water quality criteria at each permitted outfall point and will specify storm water management practices. KUCC or its designate will continue to manage both surface water and captured groundwater of various qualities from throughout the property after closure.

1.3.4 Air Permits

The Utah Division of Air Quality (DAQ) manages Air Approval Orders and sections of the State Implementation Plan at the Mine, Concentrators and Tailings Impoundment. Air emissions at the concentrators will end at closure, though certain air quality requirements may apply during demolition and reclamation. The level of dust emissions from the mine, waste rock disposal areas and tailings impoundment will be highly dependent upon the reclamation actions that are selected. It is likely that the DAQ will continue to require oversight of these facilities during and after closure.

1.3.5 CERCLA Sites and NRDC for Acid Plume

Under the terms of various EPA CERCLA administrative orders and a 1995 Memorandum of Understanding (MOU), the EPA and the State Division of Environmental Response and Remediation (DERR) provide oversight and specify minimum cleanup standards during remediation activities at historically contaminated sites. Most of these sites will be remediated and reclaimed many years before closure, but it is possible that new sites will be identified or that remediation will continue after closure at other sites.

1.4 1998 UPDATE OF MINING OPERATIONS

The final draft of the 1998 Update on Mining Operations Conducted Under DOGM Permit Number M/035/002 was submitted to DOGM on September 30, 1998. The 1998 Update describes in detail the mining operations that currently exist within the permit boundaries and provides a brief history of the operations since the original permit was received in 1978. This reclamation report does not describe the existing facilities in detail, because it is designed to be read in conjunction with the 1998 Update.

1.5 REPORT ORGANIZATION

This reclamation report is organized in the same general manner as the 1976 Mining and Reclamation Plan. Section 2.0 describes general reclamation strategies that are common to each land use category described in the original plan. Sections 3.0 through 9.0 describe the issues, data requirements and decision making processes needed to select the tentative reclamation options presented for each land use category. Section 10.0 describes CERCLA Sites and Section 11.0 briefly describes future and on-going research that is being conducted in support of reclamation and closure.

2.0 GENERAL RECLAMATION STRATEGY

The following sections describe the general decision making process that will be used in the future to determine if and when a site should be reclaimed, and to select the most appropriate actions at sites that have been scheduled for reclamation.

2.1 RECLAMATION TIMING

The ultimate fate of facilities that currently exist within the permit boundaries is: 1) to be reclaimed during the life of the mine, 2) to be reclaimed during mine closure, or 3) to not be reclaimed. Table 1 presents a conceptual decision-making framework to determine if and when a facility should be reclaimed.

It may be logical to close and reclaim some facilities before general mine closure. For example, changes in process or economics may make some facilities obsolete. Facilities that reach the end of their designed operational life, such as the existing tailings impoundment, may also be reclaimed before general mine closure.

Under current plans, most facilities will be reclaimed at the time of general mine closure. However, some facilities may be left in place if they have a post-mining use and if they do not pose a threat to human health or the environment. For instance some of the existing buildings at the North Concentrator complex may be easily converted to other commercial or industrial uses following mine closure. Once process materials have been removed and the facilities have been de-contaminated, they might be sold or leased to another company.

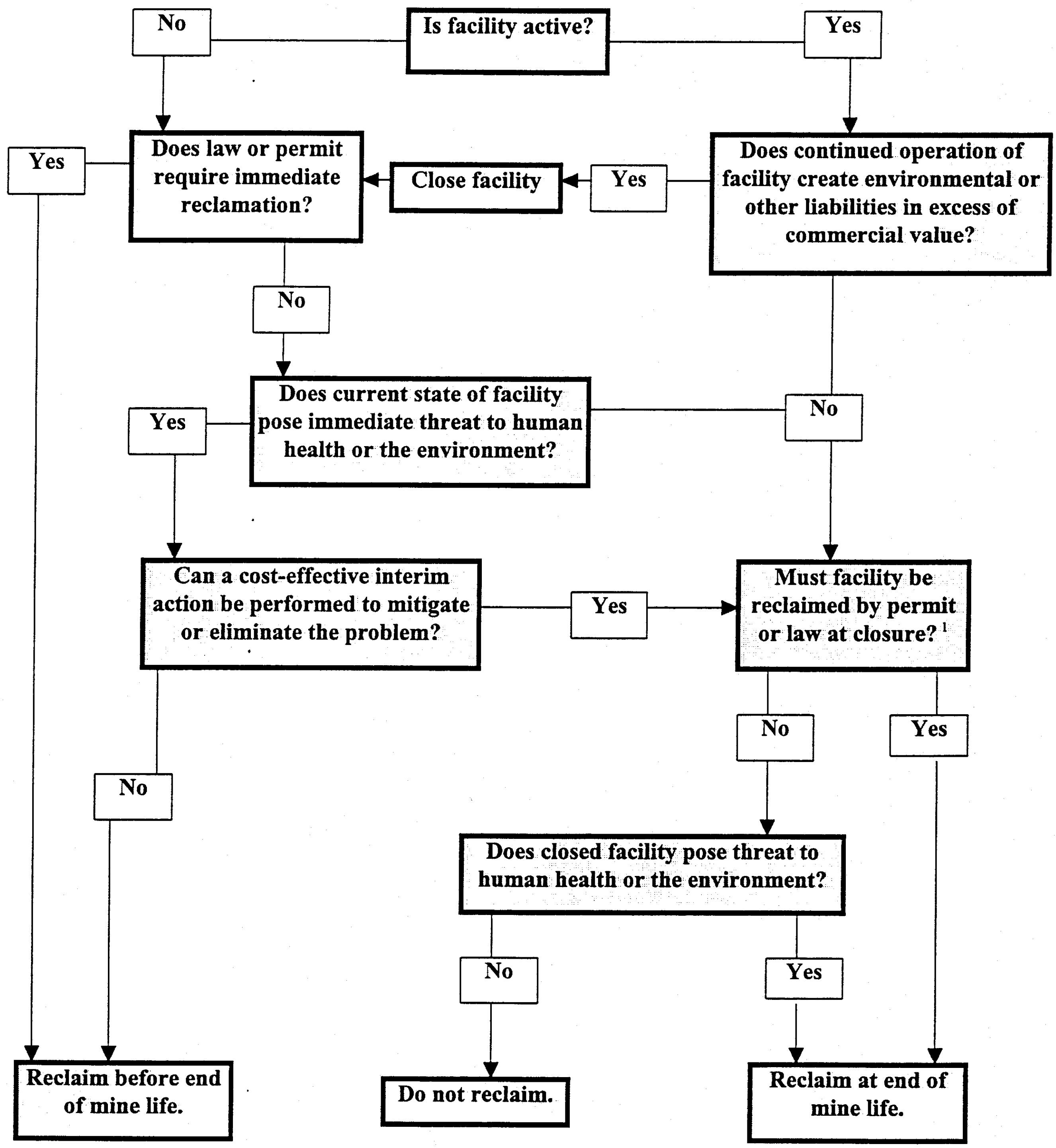
2.2 SELECTION OF RECLAMATION ACTIONS

Tentative reclamation actions for each land use category specified in the 1978 Permit are selected according to the following steps:

- closure issues are identified
- possible post-closure land uses are identified
- a general reclamation strategy and decision-making framework is described
- information that is needed before final closure options can be selected is identified
- tentative reclamation actions are selected.

The following subsections provide a general description of each of these steps. Sections 3.0 through 9.0 are also organized according to the format described here.

Table 1 – Flow Chart for Reclamation Options



Note 1. According to the 1976 Reclamation Plan, most facilities must be reclaimed unless they have a post-mining use.

2.2.1 Closure Issues

Regulations and permits governing closure, in particular, actions required by the 1976 Mining and Reclamation Plan, are identified for each land use category. Known hazards and environmental liabilities that will exist at closure are also described, and the environmental goals of the reclamation process are listed.

2.2.2 Possible Post-Closure Land Uses

Possible post-closure land uses are identified based upon the limitations imposed by the regulatory and physical setting that will exist at closure. In the future, land use may also be selected based upon cleanup standards derived from exposure and risk assessments. Sites without long-term maintenance requirements and where all physical and chemical hazards are removed, may have an unrestricted post-closure land use. At the other extreme, sites that will require continuous maintenance after closure, or that will still pose physical or chemical hazards, will have a more limited set of possible post-closure land uses. The identification of these limitations early in the planning process can help define the reclamation strategy.

2.2.3 Reclamation Strategy

The reclamation strategy lists general reclamation activities that may be conducted at a site. It then provides a decision-making framework to select a cost effective and environmentally-balanced combination of reclamation activities that will address the closure issues identified earlier. Data requirements needed to make a rational selection of reclamation actions are also identified.

2.2.4 Data Requirements

This section identifies information that is not currently available but is needed in order to implement the reclamation strategy and select reclamation actions.

2.2.5 Tentative Reclamation Actions

Tentative reclamation actions are selected for each land use category based upon the incomplete data set that is currently available. These actions will be modified in the future as necessary data requirements are filled and as new technologies become available.

2.3 RECLAMATION OF BUILDINGS AND STRUCTURES

The original Mining and Reclamation Plan submitted to DOGM in 1976 specified that all surface facilities, utilities, railroads, paved areas and equipment would be razed and/or removed except for those with a post-mining use. This is a common requirement to each of the operational areas specified in the 1978 Permit, and reclamation will generally be conducted in a similar fashion at each site.

Table 2 lists the major facilities and structures that currently exist within the permit boundaries, and specifies the closure approach and status currently planned for each facility. The closure approach consists of one or more activities for each facility. A brief description of the principle activities is provided below:

- Demolition (Demo) involves the removal of salvageable equipment and destruction of buildings or structures and foundations. The non-hazardous debris resulting from the building demolition will either be buried on site or placed in one of several construction-debris (Class IV) landfills to be permitted, constructed and operated on KUCC property at closure.

- Remediation (Remed) involves excavation and removal of contaminated soils. Hazardous wastes will be sent to an off-site disposal facility. Metals contaminated soils which are not hazardous will be placed in the waste rock disposal areas or buried in place if appropriate. Hydrocarbon contaminated soils will be bioremediated or sent to an off-site industrial landfill. Other, more cost effective disposal options may be identified in the future that are equally protective of the environment and consistent with future laws and regulation.

- Reclamation (Reclaim) involves regrading and revegetating affected areas.

- Leave in Place indicates that the facility will remain for future commercial or other uses.

The closure status options listed in Table 2 are:

- Interim - indicates that the facility will probably become inactive and be reclaimed before general mine closure.

- Final - indicates that the facility will probably become inactive and be reclaimed during general mine closure.

- Not Applicable (N/A) - indicates that the facility will have a post-mining use or that the final closure option has not been selected.

- Completed - indicates that the facility has already been reclaimed.

Before each facility closes, residual feedstock materials and products will be identified, collected and processed, sold or otherwise removed. During demolition, salvageable and recyclable materials will also be sold or recycled. Uncontaminated construction debris that remains after all commercially valuable materials have been removed will either be transported to a Class IV landfill on KUCC property or buried on-site. Wherever possible, construction debris will be used as fill material to minimize the need to excavate and transport fill material from elsewhere.

Soils, construction debris or other materials that are contaminated with metals or organic compounds will be properly characterized and sent to an appropriate disposal or treatment

TABLE 2 - FACILITIES AND STRUCTURES WITHIN THE PERMIT BOUNDARIES

FACILITY DESCRIPTION	CLOSURE APPROACH	STATUS
MINE		
Water Tanks	Demo/Reclaim	Final
General Buildings	Demo	Final
Lead Mine Townsite	Demo/Reclaim	Final
Lark Mine Buildings	Demo/Reclaim	Final
Yosemite Road	Leave in Place or Reclaim	N/A
Yosemite Truck Shop & Dispatch Tower	Demo/Reclaim	Final
Explosive Storage (IRECO)	Demo/Reclaim	Final
Dry Fork Warehouse & Shops	Demo/Reclaim	Final
In-Pit Crusher	Demo	Final
6190 Truck Shop	Demo/Reclaim	Final
Code 80 Fuel & Lube Shop	Demo/Reclaim	Final
Miscellaneous Shafts	Demo/Reclaim	Final
44 KV Power Distribution Line	Leave in Place	N/A
Miscellaneous Tunnels	Demo/Reclaim	Final
Asphalt/Concrete Parking Areas	Demo/Reclaim	Final
MINE WASTE DISPOSAL		
Small Bingham Reservoir	Leave in Place	N/A
Large Bingham Reservoir System	Leave in Place	N/A
Precipitation Plant	Demo/Remed/Reclaim	Final
Water Management System Facilities	Leave in Place	N/A
Leach Water Collection System Facilities	Leave in Place	N/A
Leach Storage Pond	Demo/Reclaim	Final
Pilot-Scale Water Treatment Facilities	Demo/Reclaim	Interim
SX-EW Pilot Plant	Demo/Reclaim	Interim
Asphalt/Concrete Parking Areas	Demo/Reclaim	Final
EXCESS MINE WATER DISPOSAL		
Evaporation Ponds and Associated Facilities	Demo/Remed/Reclaim	completed
ORE TRANSFER-MINE TO PROCESS		
Central Yard	Demo/Reclaim	Final
Rail Tracks and ties	Demo/Reclaim	Final
Rail Ballast	Remed/Reclaim	Final
Asphalt/Concrete Parking Areas	Demo/Reclaim	Final
ORE PROCESSING FACILITIES		
Magna Concentrator	Demo/Remed/Reclaim	Final
Pump Station 3	Demo/Reclaim	Final
Magna Asphalt/Concrete Parking Areas	Demo/Reclaim	Final
Arthur Shops	Demo/Reclaim	Final

TABLE 2 - FACILITIES AND STRUCTURES WITHIN THE PERMIT BOUNDARIES

Arthur Stills	Demo/Reclaim	Interim
Arthur Settling Basins	Demo/Reclaim	Interim
Arthur Warehouse	Demo/Reclaim	Final
Arthur Administration Building	Demo/Reclaim	Final
Central Laboratory	Demo/Reclaim	Final
Arthur Asphalt/Concrete Parking Areas	Demo/Reclaim	Final
Primary Crusher (Dumper Building)	Demo/Reclaim	Final
Bonneville Process Water Pond	Demo/Reclaim	Final
Symons Building	Demo/Reclaim	Final
Bonneville Fine Ore Storage	Demo/Reclaim	Final
Bonneville Mill Building	Demo/Reclaim	Final
Pipelines	Demo/Reclaim	Final
Bonneville Asphalt/Concrete Parking Areas	Demo/Reclaim	Final
TAILINGS DISPOSAL		
Magna Tailings Pond Structures	Demo/Reclaim	Interim
EXCESS PROCESS WATER DISPOSAL		
Excess Process Water Disposal Structures	Leave in Place	N/A

facility. Selected materials may be decontaminated and recycled. Hazardous materials will be sent to an off-site hazardous waste landfill. According to their chemical characteristics, other materials will be bioremediated, sent to an industrial landfill, or sent to the waste rock disposal areas. Contaminated materials will be handled in compliance with all existing permits and regulations. However, within this legal framework, material handling decisions will be based upon cleanup standards derived from exposure and risk assessments. For example, if the post-mining land use is industrial, then the cleanup standards for soils will address industrial worker exposures. If the post-mining land use is wildlife habitat, the clean up standards will be based upon exposures to potentially impacted species.

After demolition and remediation activities have been completed, most sites will be reclaimed, except for those located on the waste rock disposal areas. Where necessary, fill material will be imported, drainages will be reconstructed, and the land surface will be graded and contoured consistent with the surrounding terrain. If the existing soils or fill materials do not provide a suitable growth media, topsoil will be imported and spread. Wherever possible, topsoil will be taken from nearby existing stockpiles. Reclaimed sites will be planted with native and select non-native species. Species mixes will be adjusted based upon parameters such as elevation and slope orientation.

3.0 MINE AREA

The Bingham Pit is currently about 13,000 feet across at its widest point and covers approximately 2270 acres. The associated support facilities cover about 170 acres and are generally sited on top of old waste rock disposal areas adjacent to the pit. A list of the support facilities is provided in Table 2. The open pit extends from approximately 8000 feet above mean sea level (amsl) to about 4800 feet amsl. Pit slopes will range between 32 and 52 degrees at closure and will be composed of a series of benches that average 50 feet high and 56 feet wide. Currently two major tunnels connect the pit with the Salt Lake Valley: the Conveyor Tunnel with a portal at 5490 feet amsl in the pit, and the railroad tunnel with a portal at 5840 feet amsl. The head of the Elton Tunnel is at an elevation of 5150 feet amsl and comes within 5000 feet of the pit walls. The Elton tunnel was originally designed to dewater the underground workings on the northwest side of the pit to the Tooele Valley, but it is currently collapsed in at least one location.

According to the current surface mine plan, the pit will be approximately 500 feet deeper and cover several hundred additional acres at closure. If underground block cave mining is performed after the termination of surface mining, many of the existing pit walls will become highly fractured and will be dropped down several hundred to several thousand feet depending upon their proximity to the block caving operation.

The distribution of sulfide mineralization within the walls of the Bingham pit are a primary control on contact water chemistry and on the chemistry of soils that form on the pit benches. As the sulfides are oxidized, they produce acid which may be neutralized in situ if sufficient acid neutralizing minerals such as calcium carbonate are present in the rock. Exposures in the Bingham Pit indicate that the current pit walls are net acid-neutralizing below about 5200 feet amsl, are net acid-generating between 5200 and 7000 feet amsl, and are net acid-neutralizing again above about 7000 feet amsl. The pyrite halo around the ore body, where rock has the strongest potential to generate acid is largely confined to a band between 5500 and 6500 feet amsl. In plan view, the distribution of acid/base accounting (ABA) potential in the pit can be visualized as donut shaped, with a positive (net-neutralizing) 2500-foot diameter core surrounded by a strongly negative (net acid-generating) 10,000-foot diameter ring. As mining continues it is anticipated that more and more of the net neutralizing core will be exposed in the bottom of the pit. At closure the rock exposed in the lower 900 feet of the pit will likely be net neutralizing.

Surface and ground water inflows into the pit currently average about 1200 gallons per minute (gpm). Dewatering of the pit, along with pumping from underground workings surrounding the pit, have created a large cone of depression in the groundwater table and caused radial flow towards the the pit from all surrounding areas. These waters are currently pumped out of the pit and used in the process water circuit at the concentrators.

At closure, if other pumping on the perimeter of the pit is discontinued, the estimated inflow will be about 1700 gpm. Water quality from different areas on the pit walls is variable depending on the characteristics of the bedrock with which the water has come into contact, and its residence time on the surface or within the surrounding rock mass. However, the long-term average water quality in the pit is probably similar to that of the lake that formed in the bottom of the pit during the shutdown in the mid-1980s. Typical values for this water were: pH, 6.0; total dissolved solids (TDS), 2500 mg/L; sulfate, 1500 mg/L; copper, 10 mg/L; and cadmium 30 ug/L. This water does not meet water quality standards acceptable for irrigation, drinking water or discharge to surface water. It also does not meet water quality standards for the aquifers in the southwestern Jordan and Tooele valleys. At closure, when this water is no longer used in the process water circuit, it may have to undergo some form of treatment for pH, TDS, sulfate, copper and trace metals before it can be released from the property.

3.1 CLOSURE ISSUES

The original Mining and Reclamation Plan submitted to DOGM in 1976 specified the following activities for the mine area at closure:

- pit sides will be stabilized at a slope of 30 to 50 degrees from horizontal
- it is unlikely that the pit will be revegetated because most of the exposed surface will be solid rock containing natural sulfide mineralization
- surface facilities including buildings, railroad tracks, power lines and poles and equipment will be removed.

The primary closure issues at the pit are driven by the need to insure long-term groundwater and surface water quality protection. The most significant water management issues are:

- insuring that contaminated water does not escape from the pit into the surrounding groundwater system
- insuring that any surface water discharges from the pit meet water quality criteria
- minimizing ecological risks posed by water that may accumulate in the pit.

The mine has also been placed on the National Historic Register. Its importance as a National Historic Site may limit significant modifications of the pit at closure. This may also require that public access be permanently maintained to some point within the pit. However, safety considerations around steep and potentially unstable areas on the pit walls will require the public be excluded from most of the mine area.

3.2 POSSIBLE POST-CLOSURE LAND USE

Based upon the requirement for long-term water management in and around the mine, and the public safety issues associated with steep and potentially unstable areas on the pit walls, post-mining land uses will, by necessity, be limited.

Whatever final closure scenario is ultimately selected, the entire open pit will have to be a water management facility with limited public access. Parts of the pit where vegetation can become established will also become wildlife habitat, and selected areas of the pit may be established as public access points to the National Historic Site.

Under closure scenarios that involve a dry pit, various commercial activities may be continued in the pit after closure. For instance, if block cave underground mining is conducted, a large, subsurface water collection system will be in place that is located at the base of several thousand feet of highly fractured copper-bearing wall rock. It may be economical to keep the pit dewatered while recovering copper from the leachate that percolates through the fractured bedrock.

3.3 RECLAMATION STRATEGY

The reclamation strategy for the mine area will be designed to address the issues listed in Section 3.1 in the most cost effective manner. To comply with the 1976 DOGM Plan, all surface structures and debris in the mine area will have to be removed except for those with a post-closure use. To insure public safety, access must be controlled. To protect groundwater quality, radial groundwater flow into the pit must be maintained in perpetuity. This could be accomplished by either keeping the pit dewatered or allowing a terminal lake to become established in the pit. To protect surface water quality, all waters that are removed from the pit, whether by pumping or gravity flow, will likely have to be treated to meet water quality criteria.

Within the limits established by these conditions a huge number of potential closure scenarios based upon combinations of activities are possible. Ultimately, the pit could be continuously dewatered, allowed to flood to the maximum level possible which still maintains a terminal lake, or allowed to flood to some intermediate level. A partial list of other possible post-closure activities includes: capturing and diverting clean surface and groundwater up gradient from the pit; revegetating selected benches on the pit walls; modifying selected pit benches to capture and divert surface water; or chemically treating selected pit benches to minimize acid rock drainage (ARD). Each activity will influence water chemistry, slope stability, long-term energy consumption, surface water discharge volumes and possible post-closure land uses differently. The closure scenario that is finally selected will be some combination of these and/or other activities which balances initial and long-term costs, potential short- and long-term revenues, and environmental costs and benefits in a technologically sound manner.

3.4 DATA REQUIREMENTS

In order to select a final closure scenario the following data requirements will have to be addressed:

- final geometry of the ultimate pit, in particular if underground mining is undertaken before closure

- acid/base accounting geochemistry of ultimate pit walls

- hydrogeology of the post-closure pit, in particular to what level the pit can be flooded and still maintain a terminal lake, the expected water inflows and outflows at each flooding level, and what the equilibrium level of the lake would be if no water were allowed to escape

- geochemistry of the final pit lake, in particular how lake and outflow water chemistry would vary with pit flooding level

- condition of the Elton Tunnel, in particular, the amount of rehabilitation required to use this tunnel to dewater the pit, and the water quality that would be produced by gravity drainage from the bedrock and alluvium surrounding the 24,000-foot long tunnel

- identification of new technologies, such as sulfide passivation, which may become available between now and closure.

Unfortunately, most of these data requirements cannot be addressed until the mine is nearing the end of its life and the ultimate characteristics of the pit can be predicted with more certainty.

3.5 TENTATIVE RECLAMATION ACTIONS

Tentative reclamation actions have been selected based upon the existing incomplete data set and on the assumption that the current mine plan adequately predicts the ultimate geometry of the pit.

All surface facilities including buildings, railroad tracks, power lines and equipment will be removed from the mine area at closure. Reclamation of these facilities will be conducted as described in Section 2.3. The only facilities that may be left in place are those related to long-term water management or directly related to public access to the National Historic Site. These facilities may include water pipes, tanks, pumphouses, some repair shops, offices, access roads and the Visitors Center. Public access to most of the pit will be limited with a combination of engineering and institutional controls. Roads will be blocked off, and fences and signs will be erected.

The pit will be allowed to flood to the elevation of the Elton Tunnel at 5150 feet amsl, the Conveyor Tunnel at 5490 feet amsl or some intermediate elevation. This will allow gravity flow out of the pit or pumping with a relatively small lift requirement. If technically and economically feasible, the 24,000-foot long Elton Tunnel may be rehabilitated and a 5000-foot connection may be driven between the tunnel and the pit. The pit will then be allowed to flood to 5150 feet amsl. It is estimated that it will take at least 50 years for the pit to flood to this level and begin to drain. This would create a lake almost 900 feet deep and covering about 500 acres. Alternatively, the Conveyor Tunnel may be used to drain water from the pit if use of the Elton Tunnel proves unpracticable, or if subsequent geochemical and hydrologic studies indicate this to be the preferred alternative. If the ultimate pit were flooded to this level, it would create a lake about 1200 feet deep, with a surface elevation of 5490 feet amsl and covering about 700 acres. This tunnel would require much less modification at closure than the Elton Tunnel.

Use of the Elton Tunnel will be more likely to create a terminal lake with radial flow from all of the surrounding bedrock. Water quality might also be enhanced at this lower level because the surface of the lake will be below the base of the pyrite halo. The cone of depression created in the surrounding bedrock by a lake at 5150 feet amsl would keep most of the pyrite halo dewatered in perpetuity. Use of the Conveyor Tunnel would still keep most of the pyrite halo dewatered, but the surface of the lake would be in contact with the base of the halo. Whichever outlet is used, the lake will lose water by evaporation and by gravity flow through a tunnel to either the Salt Lake or Tooele valleys. A water treatment facility will likely be necessary to treat the outflow to acceptable levels for release or sale. It is currently assumed that a lime treatment plant with clarifiers and sludge densification facilities will be used, but other preferred technologies may become available in the future. An estimated flow of 1700 gpm from the pit will have to be treated in perpetuity. The chemistry of this water would probably be similar to that of the pit lake that formed in the 1980s (Section 3.0). If the Elton Tunnel is used, it will also drain bedrock and alluvium along its length, adding an estimated additional 3000 gpm of flow. This water may be of suitable quality to sell or release without treatment, but no water quality data are currently available.

Wells and surface diversion structures will be sited around the perimeter of the pit to capture clean surface and groundwater before it becomes contaminated through contact with mineralized rock. These facilities will generally be sited on the west side of the pit between the mine and the range crest of the Oquirrh Mountains. Wells will be located in areas where groundwater quality is sufficient to allow its sale to local municipalities and purveyors for beneficial use with little or no treatment. Pumping limitations will be placed on all wells to prevent gradient reversals and the migration of contaminated groundwater from the vicinity of the pit.

Selected pit benches that are overlain by suitable soils will be planted with seedlings or seeded. Reclamation activities will be limited to benches that are underlain by net-neutralizing or weakly acid-generating bedrock and where some fine-grained material has accumulated during the natural weathering of the rock. This will generally restrict the revegetation efforts to areas above 7000 feet amsl on the pit walls, but locally benches as low as 6500 feet amsl may be suitable. Approximately 700 acres in the upper pit may have acceptable soil chemistry, but because of other limitations, less than half of this total area is estimated to be suitable for revegetation.

4.0 MINE WASTE DISPOSAL AREA

The mine waste rock disposal area currently covers about 5080 unreclaimed acres and contains approximately 3.5 billion tons of material. An additional 600 acres at the foot of the Eastside dumps have already been reclaimed. About 250 acres surrounding the disposal areas are being used to manage leach water and meteoric water flows that have contacted the waste rock. A list of the support facilities associated with the disposal areas and water management systems is provided in Table 2. The large angle-of-repose (35 to 37 degrees) slopes on the margins of the waste disposal areas are the most prominent visual features from the Salt Lake Valley, but they actually cover less than forty percent of the total disturbed area. The highest inactive slope is 1200 feet high, but currently no active slopes are higher than 500 feet. Most of the disposal area is composed of flat to slightly irregular waste rock surfaces.

Future mine plans call for the placement of one billion additional tons of waste rock before mine closure. The majority of this material will be placed in Bingham Canyon or in lifts on top of existing disposal areas.

Mine waste is composed of a mixture of intrusive rocks, quartzite, limestone and limestone skarn. Except for copper, average metals concentrations are relatively low, as illustrated from a 66-sample average for the following elements: arsenic 31 mg/kg, barium 70 mg/kg, cadmium 2.0 mg/kg, chromium 55 mg/kg, copper 809 mg/kg, lead 380 mg/kg, selenium 2.6 mg/kg and zinc 311 mg/kg. The average sulfide concentration, predominantly pyrite, in unweathered rock from the pit is about four percent, but waste rock exposed on the surface of the disposal areas only contains an average of one percent unoxidized sulfides. Soils forming on the waste rock have paste pH values between 2 and 8; and paste conductivities, a measure of soil salinity, of between 20 and 9000 umhos/cm. The primary controls on soil pH are the percentage of sulfides in the waste rock, the percentage of limestone in the waste rock and the age of the waste rock surface on which the soil is forming. The primary controls on soil conductivity are the percentage of sulfides in the rock and the age of the waste rock surface. In general, the older the waste rock surface, the lower the pH and the lower the conductivity. In some areas, thin vegetation has voluntarily established itself on waste rock surfaces with pH values above about 4.5 and conductivities below about 400 umhos/cm. These favorable areas cover about 700 acres or 15 percent of the waste rock disposal area. They are generally located on the south and southeast sides of the pit, and at higher elevations on the Eastside disposal area. Waste rock that was deposited in these areas was mined from higher, less mineralized benches in the pit.

A long-term average of about 20,000 gpm of leach water is continuously recirculated between the Precipitation Plant and the waste rock disposal areas for copper recovery. The leach water is captured by a series of State-permitted cutoff walls, sumps, drains, basins and pipes at the foot of the waste rock disposal areas. Groundwater and precipitation that infiltrate the disposal areas is acidified (becoming ARD) and reports to the down gradient water collection systems. It is estimated that without leaching operations, there would still be an ARD base flow of about 1000 gpm emanating from the disposal areas. This ARD typically has a pH of less than 4.0 and TDS concentrations of greater than 10,000 mg/L. Meteoric waters that run off the surface of the waste rock disposal areas are also captured by the down gradient water collection systems. This contact meteoric water typically has pH values between 4.0 and 7.0, and TDS concentrations between 1500 and 10,000 mg/L. The average flow of this water is estimated to be 1200 gpm. Non-contact water is surface runoff and groundwater flow that has not come into contact with sulfide bearing rock. This water is currently captured on the up gradient side of the waste rock disposal areas and the Bingham Pit. It typically has TDS concentrations of less than 1000 mg/L and near neutral pHs. Current flows range from a high of 30,000 gpm during peak runoff events to a baseline flow of about 1000 gpm, exclusive of pit dewatering. All of these flows, except for water in the leach circuit, are currently routed to the concentrator process water circuit. During peak runoff periods, excess water is temporarily stored in the Large Bingham Reservoir.

Severe erosional events and failures have occurred on various waste rock slopes in the past. Since the termination of active dumping on the high slopes facing the Salt Lake Valley in 1984 the frequency and magnitude of slope failures have decreased. However, several shallow surface slumps and debris flows have occurred in the past decade. Precipitation greater than the 25 year, 24 hour storm event that falls on the slopes may also exceed the capacity of the down gradient storm water and sediment collection systems. In such cases, contaminated water and sediment may escape KUCC property. Severe erosional events also fill the water collection systems with sediment increasing the frequency and cost of maintenance. In the past decade these events have most commonly occurred on the waste rock disposal areas above Butterfield Creek on the southeast side of the pit.

4.1 CLOSURE ISSUES

The original Mining and Reclamation Plan submitted to DOGM in 1976 specified the following activities for the mine waste disposal area at closure:

- all dumps will be left in a safe and stable condition
- collection systems will be provided to contain natural seepage in the area
- dikes and ponds will be constructed on the upper levels of the dumps to prevent slope wash and possible mud slides
- no major revegetation is planned because the majority of the waste material contains natural sulfide mineralization
- if and when revegetation practices or methods are developed which would make vegetation economically practicable, such practices and methods will be employed on the dumps
- when no longer needed in mining, mineral extraction or subsequent operations, surface facilities including buildings, above ground utilities, railroads, piping and equipment will be removed.

Current permits and regulations require KUCC to control contact water flows from the waste rock disposal areas in order to protect surface and groundwater quality. The goal of these regulations is to prevent any unpermitted discharge of contaminated water or sediment from the property. After closure, KUCC will continue to maintain the existing groundwater and surface water collection systems at the foot of the disposal areas to comply with all applicable requirements. In order to insure compliance after closure in the most cost effective manner, the following goals must be considered during closure planning:

- insure that catastrophic events cannot compromise the water collection systems or transport contaminated water and sediment off KUCC property

- reduce long-term ARD generation from the disposal areas to minimize the risk of down gradient groundwater contamination and long-term water handling and treatment costs

- minimize the loading of sediment and debris from the disposal areas to reduce long-term maintenance costs for the water collection systems.

Other requirements that will probably remain in place after closure are the continued recovery of contaminated water from beneath the Dry Fork waste rock disposal area and from the Bingham Creek groundwater plume.

Potential physical hazards on the waste rock disposal areas will require that public access be restricted after closure. Unless all slopes are reduced there will be steep and potentially unstable areas that pose hazards to the general public.

4.2 POSSIBLE POST-CLOSURE LAND USE

Based upon the requirement for long-term water management on and around the waste rock disposal areas, the acidic nature of the waste rock, and the public safety issues associated with steep slopes, post-mining land uses in these areas will, by necessity, be limited.

Whatever final closure scenario is ultimately selected, most of the waste rock disposal areas will likely be operated as a water management facility with limited public access. Those parts of the disposal area that have favorable soils, or where favorable soils have been created, may be revegetated to become wildlife habitat.

4.3 RECLAMATION STRATEGY

The reclamation strategy for the waste rock disposal areas will be designed to address the issues listed in Section 4.1 in the most cost effective manner. To comply with the 1976 Plan, all surface structures and debris in the area will have to be removed except for those with a post-closure use.

The existing groundwater, surface water and sediment collection systems at the base of the disposal areas will continue to operate after closure. Up gradient systems such as the clean water collection system in the Dry Fork drainage will also continue to operate after closure. Specific sections of both systems may be enlarged or modified if they are found to be incapable of handling recurring peak flow events or to require excessive amounts of maintenance. In order to reduce ARD, run off, and sediment that must be handled by the down gradient system, selective reclamation of the overlying waste rock disposal areas will also be considered.

Table 3 lists general reclamation options and specific techniques. The local site conditions at any given location on the disposal area surface will limit the reclamation techniques which are viable at that location. Parameters which may limit reclamation options include: soil chemistry, physical soil characteristics, slope angle, slope stability, slope orientation, elevation, geographic location, and surface and groundwater flow regimes. In general, the least costly reclamation technique that will still yield the desired result will be utilized at each location.

On flat surfaces, the selection of reclamation alternatives will generally involve an analysis of potential downstream reductions in ARD that must be captured and treated. On waste rock slopes, this will require a more rigorous comparison of slope reclamation requirements with the probability of catastrophic events releasing contaminated materials from the property, potential reductions in peak runoff events, potential reductions in maintenance costs, and potential reductions in ARD that must be captured and treated. The relation between these issues is illustrated on Table 4. In theory, this approach will focus reclamation activities in areas where the greatest benefit can be derived at the least cost.

4.4 DATA REQUIREMENTS

In order to design a cost-effective reclamation process for the waste rock disposal areas the following data requirements will have to be filled:

- final geometry of the waste rock disposal areas, in particular the location and soil chemistry characteristics of future waste rock piles
- base ARD flows from various parts of the disposal area (not including flows from the active leaching circuit)
- relative effects of each reclamation technique on infiltration and runoff
- the soil chemistry limitations of each reclamation technique
- identification of new reclamation technologies which may become available between now and closure.

Many of these data requirements are being addressed by ongoing reclamation programs on the waste rock disposal areas and by the operation of pilot-scale water treatment facilities. Others

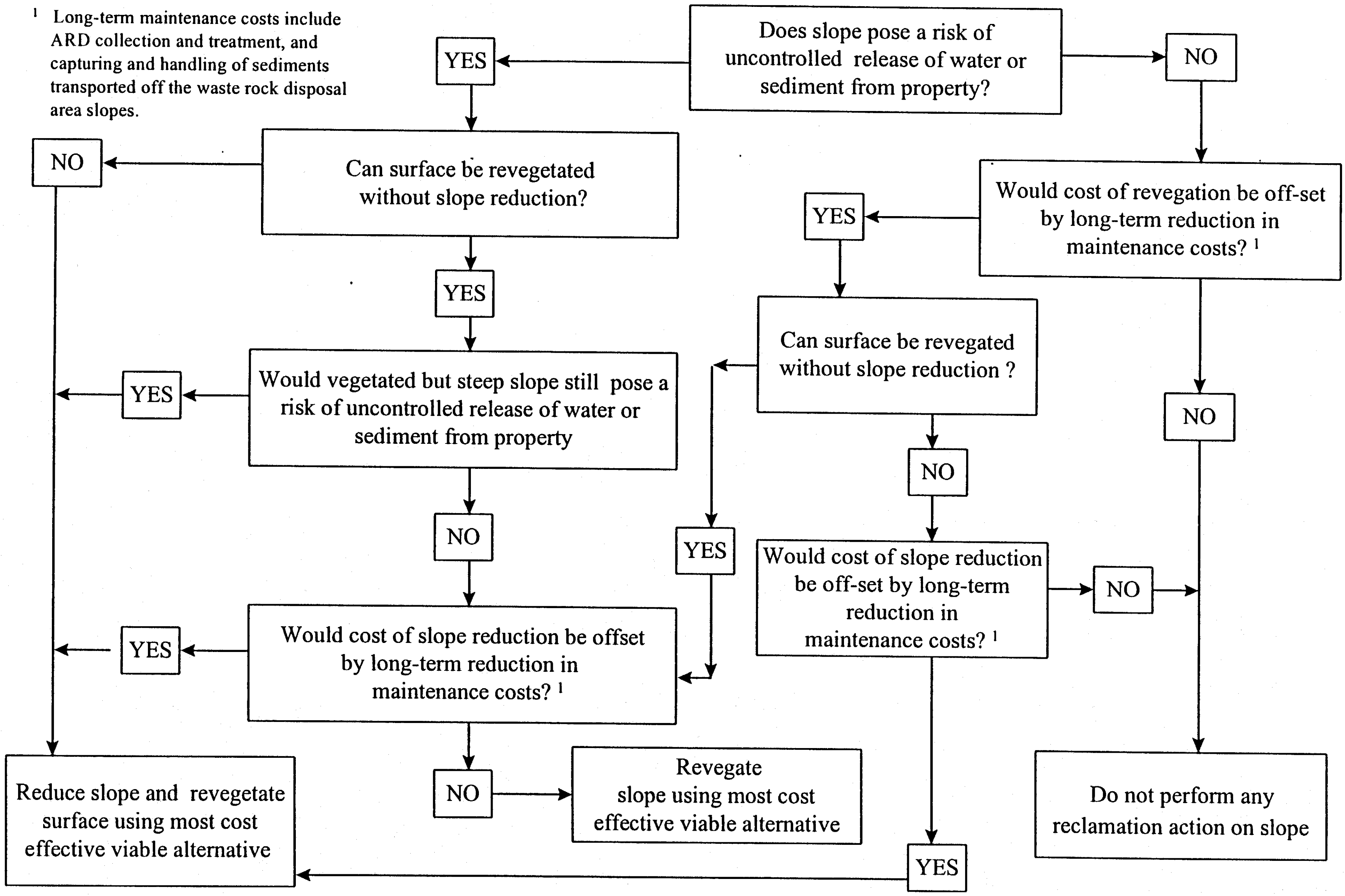
TABLE 3 - RECLAMATION OPTIONS FOR THE WASTE ROCK DISPOSAL AREAS

RECLAMATION OPTIONS	RECLAMATION TECHNIQUES [1]
Planting without soil modification	- Plant seed - Plant mycorrhizae - inoculated seed - Plant tree and shrub seedlings - Plant mycorrhizae - inoculated seedlings - Other planting techniques not yet identified
Soil modification before planting	- Fertilizer Application - Biosolids Application - Use of a soil pitter - Lime Application - Capping with inert or net-neutralizing waste rock - Capping with imported soil or manufactured soil - Other techniques not yet tested such as sulfide passivation
Surface modification to control water movement	- Surface regrading to direct runoff away from steep slopes - Surface regrading with runoff collection systems - Capping with sulfide rich material to form an impermeable layer - Capping with imported low permeability material - Capping with composite material - Other surface modification techniques not yet identified
Slope modification and reduction	- Armor dump slopes with coarse geochemically inert material - Passive slope reduction with engineering controls at foot of slope - Cast blasting - Conveyor and stacker systems - Drag line technology - Earth moving with heavy dozers - Other slope reduction techniques not yet identified

[1] For each option the techniques are listed in order of generally increasing cost and generally decreasing limitations

TABLE 4 - FLOW CHART FOR DECISIONS ABOUT WASTE ROCK DISPOSAL AREA SLOPES

[1] Long-term maintenance costs include ARD collection and treatment, and capturing and handling of sediments transported off the waste rock disposal area slopes.



such as the base flow of ARD from specific areas and the final geometry of the waste rock surface cannot be determined until some operations have been shut down.

4.5 TENTATIVE RECLAMATION ACTIONS

Tentative reclamation actions have been selected based upon the existing incomplete data set and on the assumption that the current mine plan adequately predicts the final geometry of the waste rock disposal area.

The conventional leaching circuit on the waste rock disposal area will be shut down as soon as it becomes uneconomical and after economical leach water disposal methods have been identified. Once the system has drained down, base flows of natural ARD from each part of the disposal area can be determined, and a long-term base flow database will be developed. This will allow one of the data gaps identified in Section 4.3 to be filled.

All surface facilities without a post-closure use will be removed from the waste rock disposal area at closure. Reclamation of these facilities will be as described in Section 2.3. Based upon current assumption of post-mining use, the only facilities that may be left in place will be those related to long-term water management such as the Large and Small Bingham Reservoirs, cutoff walls, sumps, drains, settling ponds and associated pipes and lined ditches. Public access will be controlled with a combination of engineering and institutional controls. Roads will be blocked off, and fences and signs will be erected.

Boundaries?

The surface and groundwater collection systems up gradient and down gradient from the disposal areas will continue to be operated in perpetuity after closure. Additional wells and surface diversion structures may also be sited up gradient from disposal areas if justified by the quality and quantity of water that can be diverted. Waters that cannot be sold or discharged without treatment will be treated at a facility located adjacent to the Large Bingham Reservoir. It is currently assumed that a lime treatment plant with clarifiers and sludge densification facilities will be used, but other more economical technologies may be identified in the future. This facility will be designed to handle the following estimated flows: 1000 gpm of ARD, 1200 gpm of contact meteoric water, 250 gpm from the acidic groundwater plume beneath the Dry Fork disposal area, and 250 gpm of acidic groundwater from the core of the Bingham Creek plume. The estimated 1700 gpm that will discharge from the pit will also be treated at this facility if the Conveyor Tunnel is used (Section 3.5).

All flat waste rock surfaces will be bermed and contoured so runoff is diverted away from steep slopes. Water collection systems will be installed on selected surfaces which are large enough, and from which water can be cost-effectively conveyed to existing water collection facilities. Unstable slopes that pose a risk to the down gradient water collection facilities and that cannot be stabilized by revegetation or another method may be reduced in slope to no steeper than 2.5 horizontal to 1.0 vertical. Selected dump surfaces with favorable soils will be seeded or planted with tree and shrub seedlings with little or no soil modification. Up to 700 acres may be suitable for direct planting. Other suitable dump surfaces may be reclaimed after the soil chemistry has - where been adjusted by the addition of neutralizing materials, passivation products and/or biosolids. Where required, or where justified by a cost/benefit analysis, acidic surfaces may be capped with suitable materials and revegetated.

5.0 EXCESS MINE WATER DISPOSAL AREA

At present there are no areas devoted to this activity as it was defined in the 1978 Permit. Mine water generated by pit dewatering operations, surface runoff and groundwater capture other than from leaching areas is currently piped to the Copperton Concentrator and used in the process water circuit. Between 1936 and 1986 this water was sent to the South Jordan Evaporation Ponds area. The ponds were located seven miles east of the Bingham Mine, one mile south of Bingham Creek and five miles west of the Jordan River. At closure in 1986, the site contained approximately 4.6 million tons of neutralized sludges in 25 individual ponds covering 530 acres. Total metals analysis of the material showed it to contain elevated concentrations of arsenic, cadmium, copper, lead and zinc. However, batch leach testing indicated that the metal-bearing material was not leachable and therefore would not be classified as a hazardous waste. Leachable sulfate, which is not regulated, was the most significant contaminant of concern at the site because of its concentration and solubility.
Groundwater beneath the site contains elevated sulfate and total dissolved solids concentrations, but does not contain elevated metals concentrations. Much of this water is above the Utah Groundwater Quality Protection standard of 500 mg/L for sulfate but below the health limit of 1500 mg/L.

The original Mining and Reclamation Plan submitted to DOGM in 1976 specified the following activities for the excess mine water disposal area at closure:

- stabilization will be accomplished consistent with subsequent land use and may include removal or covering of accumulated salts, treatment with neutralizer, grading and revegetation work

- the area will be left in a safe, stable condition suitable for future use and without hazard of erosion or surface water accumulation

- any revegetation work would likely be accomplished to suit farming requirements.

5.1 COMPLETED RECLAMATION PROGRAM

In 1994 and 1995, KUCC reclaimed the evaporation ponds with oversight by EPA and DERR. A completion certificate for this removal has been issued by the EPA. Some of the material in the ponds was returned to the waste rock disposal areas at Keystone Notch or was placed in the Bluewater I Repository. The remaining materials, composed of gypsum and gypsum-contaminated soils, were consolidated into a 210 acre low mound within the northern footprint of the ponds. The entire area was regraded, and the mound was capped with three to five feet of clean topsoil and seeded. During the reclamation an estimated 7.9 million cubic yards of contaminated soils were moved and 4.2 million cubic yards of clean soil were emplaced. No further reclamation work is planned at this site.

The removal of materials with elevated metals concentrations, and the consolidation and capping of the remaining sediments, has eliminated this site as a source of groundwater contamination. Infiltration of precipitation and irrigation canal water in the area is diluting and dispersing the remains of the historic sulfate groundwater plume.

5.2 POST-CLOSURE LAND USE

The majority of the excess mine water disposal area can now be used for non-mining purposes without restriction. Most of the reclaimed site has been returned to agricultural usage, but in the future it may also be used for residential, recreational, commercial, industrial or other purposes. The 210 acre area containing capped gypsum-bearing material should not be irrigated because this could transport sulfate to groundwater. However, in the future, this land may be used for almost any purpose that does not involve intense irrigation.

6.0 ORE TRANSFER AREA - MINE TO PROCESS

Ore is transferred 15 miles by standard gauge rail from the Mine to the North Concentrator. The track and railroad maintenance facilities associated with ore transfer cover about 330 acres. The railway network and operations are largely the same as described in the 1978 Permit. The entire ore haulage track is owned by KUCC and is within the permit boundaries.

6.1 CLOSURE ISSUES

The original Mining and Reclamation Plan submitted to DOGM in 1976 specified the following activities for the ore transfer area at closure:

- at such time as the railroad is no longer needed in the mining or processing operations or for subsequent use, trackage and surface facilities will be removed and the area left in a condition suitable for conversion to other use

- revegetation will be accomplished if appropriate for the subsequent use.

Some areas adjacent to the tracks may contain historic ore spillage or other materials associated with rail haulage. If left in place these materials could inhibit the reestablishment of vegetation.

6.2 POSSIBLE POST-CLOSURE LAND USE

After reclamation there will be no restrictions on post-closure land use. Much of the land will probably be returned to farming, wildlife habitat or to some other use. Some sections of track may be left in place to service sites of post-mining industrial or commercial development.

6.3 RECLAMATION STRATEGY

The reclamation strategy will be to remove the rail lines where appropriate and any potential chemical hazards from the area to allow unrestricted land use after closure. Sections of track that have a viable post-mining use will be identified and left in place. In all other areas reclamation will be completed in a manner consistent with the probable post-closure use.

6.4 DATA REQUIREMENTS

The only information still needed to select final reclamation actions is the determination of post-closure land use. In particular, segments of track that should be left in place and areas that will be returned to farming after closure will need to be identified.

6.5 TENTATIVE RECLAMATION ACTIONS

Tentative reclamation actions have been selected based upon the existing incomplete data set.

Before closure the entire ore transfer area will be surveyed for ore and other process materials. Identified materials will be removed and either processed, placed on the waste rock disposal areas or properly handled in another manner. Any other contaminated areas will be cleaned up as described in Section 2.3. Those sections of track with a post-mining use will be left in place, and all other track and buildings will be demolished. All steel and as many ties as possible will be salvaged. Any materials that are not salvageable will be properly disposed. Based upon its volume and chemical characteristics, ballast and fill material from some areas may be excavated and removed for proper disposal.

All sites except those located on waste rock disposal areas will be regraded to conform with the surrounding land surface and natural surface drainage will be reestablished. All areas will be reseeded, except for those that will subsequently be used for farming or where post-mining construction activities are planned immediately after closure.

7.0 ORE PROCESSING FACILITIES AREA

The North Concentrator consists of the Bonneville Crushing and Grinding Plant, the Magna Floatation Plant, a few remaining structures from the Arthur Concentrator and the Arthur maintenance shops and warehouse. A list of individual buildings and structures is provided in Table 2. The entire complex covers approximately 220 acres. In 1997 the complex processed 9,700,000 tons of ore and produced 229,866 tons of concentrate. The current mine plan requires that the North Concentrator remain in operation until near the end of the mine's life.

The North Concentrator Complex is located immediately west of the town of Magna, and has good access to the interstate highway and railroad systems. The area also has a well developed infrastructure including water supply systems, electrical transmission lines, sewage treatment facilities and arterial roadways and rail lines. The western limits of Magna, adjacent to the North Concentrator Complex, is zoned for heavy industrial use.

In the past, soils in and around the North Concentrator complex were contaminated with metal-bearing process materials, hydrocarbons and reagents in the course of normal operations. Soils with elevated lead and arsenic concentrations have already been identified and cleaned up at the old Arthur Concentrator, the Magna Concentrator and the Bonneville Crushing and Grinding Plant. It is possible that other contaminated soils are present beneath existing structures.

7.1 CLOSURE ISSUES

The original Mining and Reclamation Plan submitted to DOGM in 1976 specified the following activities for the ore processing facilities area at closure:

- surface facilities including buildings, utilities, railroads and equipment that are no longer needed for ore processing or related purposes and are not convertible to some other use, will be razed and/or removed

- all hazardous conditions will be eliminated and ground surfaces stabilized and planted.

In addition to these DOGM requirements several other issues should be considered during closure planning:

- at closure the land should be left in a condition which maximizes its value and minimizes restrictions that will be placed on post-closure land use

- control of storm water runoff should be maintained during and after closure.

7.2 POSSIBLE POST-CLOSURE LAND USE

The primary limits on post-closure land use are the concentration and extent of soil and groundwater contamination that remains on the site at closure. To comply with the requirements of the 1976 Mining and Reclamation Plan and to maximize the post-closure value of the land, remediation and reclamation will be designed at a minimum to allow industrial/commercial land use at closure. Within much of the disturbed area it is assumed that there will be unrestricted land use at closure that could include industrial/commercial, residential and wildlife habitat.

7.3 RECLAMATION STRATEGY

The reclamation strategy will be to select cost effective soil remediation options consistent with the DOGM requirements and consistent with the likely post-mining use. Buildings and structures with no viable post-mining use will be demolished, and facilities with viable post-mining uses will be prepared for sale or rent.

7.4 DATA REQUIREMENTS

In order to select final and detailed reclamation actions the following data requirements will have to be filled:

- the character and extent of any soil or groundwater contamination that may remain on site
- the condition and number of buildings at closure, in particular if any new construction occurs between now and closure
- the regional economic and demographic conditions at the time of closure and the viability of selling or leasing specific buildings to another party for industrial development.

7.5 TENTATIVE RECLAMATION ACTIONS

Tentative reclamation actions have been selected based upon the existing incomplete data base and assuming that no new major construction projects will occur in the North Concentrator area between now and closure.

Before closure all process materials will be processed, sold or otherwise remediated. At closure, all surface facilities including buildings, railroad tracks, power lines and equipment that do not have a viable post-mining use will be removed from the area. It is presently assumed that all of the Magna and Arthur facilities, and one half of the Bonneville facilities will be removed at closure. The remaining facilities will be used for post-mining industrial or commercial activities. Infrastructure that could be used for post-mining industrial activities will also be left in place at closure, including water supply systems, electrical transmission lines, sewage treatment facilities and arterial roadways and rail lines.

Contaminated soils and debris that are identified before or during demolition activities will be removed, treated or buried in place to allow at least industrial/commercial land use after closure. After demolition and remediation have been completed all sites will be reclaimed as described in Section 2.3.

8.0 TAILINGS DISPOSAL AREA

The existing tailings impoundment currently contains about two billion tons of material and receives about 55 million additional tons annually. The original footprint of the impoundment was about 5900 acres, of which 4840 acres are currently disturbed. The current active tailings pond covers 3610 acres and the embankment covers 2290 acres. Approximately 1060 acres of the embankment have been permanently reclaimed with trees and shrubs, and most of the remaining area has undergone interim reclamation with a mix of fast growing grasses for dust control. The top of the impoundment is almost 250 feet high and the overall embankment slope is maintained at approximately 11 degrees. About half of the tailings enter the impoundment through a peripheral discharge system designed to keep the active surface of the impoundment wet and to minimize dust generation.

The existing tailings impoundment has almost reached its operational capacity and construction of the new North Impoundment expansion began in 1996. The transition to the new impoundment is scheduled to extend from 1998 to 2004.

Samples of historical and modern tailings indicate that the tailings contain an average of 0.6 percent sulfide sulfur. If all of these sulfides were oxidized, the acid generated would consume about 19 lbs of calcium carbonate per 1000 lbs of tailings material. The sampling program also indicates that the tailings contain the equivalent average neutralization capacity of 27 lbs of calcium carbonate per 1000 lbs of material. The excess of natural neutralization potential over acid generating potential in the tailings indicates that the risk of ARD for the material is very low. On a mass basis, less than one percent of the impoundment material has the potential to become acidic. However, coarse tailings material, which generally accumulates on the margins of the impoundment near the discharge points, has a higher concentration of sulfide minerals and tends to be more acid generating than the impoundment as a whole. Although they may not acidify, an estimated 25 to 35% of the exposed tailings on the embankment have the potential to become acidic in the long term.

Except for copper, the tailings have relatively low average metals concentrations, as illustrated by a 61-sample average for the following elements: arsenic 25.1 mg/kg, barium 199 mg/kg, cadmium 0.3 mg/kg, chromium 47.3 mg/kg, copper 785 mg/kg, lead 23.0 mg/kg and selenium 1.2 mg/kg.

8.1 CLOSURE ISSUES

The original mining and Reclamation Plan submitted to DOGM in 1976 specified the following activities for the tailings disposal area at closure:

- when no longer needed for tailings deposition, mineral recovery or material source, grading and revegetation of dike slopes not already done will be completed

- the surface of the tailings pond will be stabilized using the most practicable technology available upon the termination of the deposition of the tailings.

In addition to the DOGM requirements, the primary closure issues at the existing tailings impoundment include:

- dust must be controlled from the impoundment in perpetuity
- surface water runoff and surface seepage of tailings water from the impoundment must be captured and conveyed to a designated outfall point where it must meet applicable water quality criteria to be discharged
- groundwater quality must not be degraded
- long-term slope stability must be maintained.

8.2 SUMMARY OF EXISTING CLOSURE PLANS

The existing closure plans described in Section 1.2.2 and attached in Appendices B and C detail the reclamation activities that will occur when the existing impoundment closes. The ultimate goal for the surface of the impoundment is to establish a permanent, self-sustaining vegetative cover to minimize dust generation, water infiltration and erosion, while improving wildlife habitat, slope stability and aesthetics.

Areas of the existing impoundment will be taken out of service sequentially, from west to east, to allow continued use of the decant pond until final closure of the existing impoundment. This will be done by constructing access dikes to subdivide the existing active surface. The peripheral discharge system will be reestablished on each new dike to keep the remaining active surface properly wetted. As each new area is isolated and begins to dry, it will be initially stabilized by one or more of the following methods: planting of rapid-growing grass seed, hydromulching, or temporary dust control using water or suppressants. Permanent revegetation of the surface will be conducted after the surface has dried sufficiently or in the next appropriate season.

At final closure, the flat, upper tailings surface will be constructed so that all precipitation will be retained on the surface. Captured precipitation will either infiltrate or will be removed by evapotranspiration. Water falling on the embankment and seepage that discharges from the base of the embankment, will report to the toe collection ditch. Ultimately, this water will be used in the process water circuit or will be discharged through a UPDES outfall. Groundwater monitoring will continue after closure to insure that there are no adverse impacts to groundwater quality.

More detailed descriptions of the closure activities are provided in the attached plans.

9.0 EXCESS WATER MANAGEMENT AREA

Facilities that are currently used for excess water management cover about 100 acres. As defined in the 1978 Permit under the land use category of excess process water disposal, this includes all the facilities that handle water from the tailings impoundment for disposal or recycling. Excess water from the existing impoundment is transferred from the decant pond to the clarification canal. From the canal, water flows around the southeast side of the impoundment to a pump station that returns it to the concentrators. Excess water not subject to zero discharge limitations or recycle requirements is discharged to the Great Salt Lake from three points: discharge point 001 releases water from the clarification canal, discharge point 002 releases water from the sedimentation pond on the northeast corner of the existing impoundment, and the newly constructed discharge point 007 is located on the northeast side of the north expansion. All three discharge points empty into the C7 Ditch which flows into Lee Creek and ultimately into the Great Salt Lake.

All of the other areas included under the excess process water land use category in the 1978 Permit are either closed or are only used by facilities that are not covered by DOGM permits. This includes the waste water treatment plant (WWTP) and its associated sludge lagoons. Metals-bearing gypsum sludge generated during the neutralization process at the WWTP was discharged to five lagoons. Approximately 1.1 million cubic yards of sludge are currently being moved from the lagoons to the Arthur Step Back Repository on the southwest side of the existing tailings impoundment. This repository was constructed under EPA oversight to meet the conditions of a RCRA Subtitle C facility. It will be filled, closed and capped by 2000. After the sludge has been removed from the lagoons they will be recontoured and revegetated. The WWTP is currently being utilized under EPA oversight as a support facility during demolition and decontamination activities at other sites on the north end of the Oquirrh Mountains. As specified in the MOU, the WWTP is scheduled for demolition in the year 2000.

9.1 CLOSURE ISSUES

The original Mining and Reclamation Plan submitted to DOGM in 1976 specified the following activities for the excess process water disposal area at closure:

- surface facilities that are no longer needed, and that are not convertible to some other use will be razed and/or removed
- sludge ponds and evaporation ponds will be left in a condition suitable for conversion to other uses, this may involve filling or covering, or other stabilization and revegetation work
- canals will most likely be left indefinitely for conveyance of natural surface flows and drainage to the Great Salt Lake.

After closure some of the facilities associated with excess water management will have to be used in perpetuity to handle surface water flows and seepage from the existing impoundment and the North Impoundment. It is also probable that some waters from the mine area and the mine waste disposal area will need to be routed through the existing process water disposal systems and into the Great Salt Lake. After closure all discharges will continue to be regulated under UPDES permit UT0000051 or a subsequent UPDES permit.

9.2 POSSIBLE POST-CLOSURE LAND USE

Based upon the long-term need to handle water from the tailings impoundments and possibly other areas, much of the area will be used for water management in perpetuity after closure. Much of the area will also be preserved as wetlands wildlife habitat. Selected areas, particularly those associated with process water recycling, may have an unrestricted land use after closure and reclamation.

9.3 RECLAMATION STRATEGY

The reclamation strategy will be to identify those facilities that have a post-mining use for water management and leave them in place. All other facilities will be demolished and/or reclaimed so that the area can be preserved as wildlife habitat or for some other land use.

9.4 DATA REQUIREMENTS

Some of the data requirements that will need to be filled before final post-mining closure options are selected include:

- the ultimate character of the post-mining water management system in the Oquirrh Mountains

- the final geometry of the tailings impoundments and their required water management systems.

9.5 TENTATIVE RECLAMATION ACTION

Tentative reclamation actions have been selected based upon the existing incomplete data set. After the mine, concentrators and North Impoundment are closed, outfalls 001 and 002 may be closed, in which case, all waters would likely be released to the Great Salt Lake through outfall 007. Outfall 007 will be maintained in perpetuity to discharge water from the tailings impoundments and from other sources in the Oquirrh Mountains. Waters from the mine and the mine waste disposal areas will likely be transported north in existing pipelines within the tailings pipeline corridor. Most existing canals and ditches will be left in place to use for water management and to provide wildlife habitat. Structures currently associated with process water recycling, such as pump houses, will be removed unless they are determined to have a post-mining use. All buildings and structures that do not have a post-mining use will be demolished and reclaimed as described in Section 2.3. The WWTP and its associated sludge lagoons will be remediated and reclaimed many years before closure, pursuant to the terms of the CERCLA removal order.

10.0 CERCLA SITES

As discussed in Section 1.3.5, the MOU between KUCC, EPA and UDEQ specified a series of remedial response actions within and adjacent to the permit boundaries. Completion of all the required environmental response actions is anticipated by 2002, however it is possible that some sites will remain to be cleaned up during general mine closure.

Settlement of the Natural Resources Damage Claim made by the State of Utah for the Bingham Creek Groundwater plume requires, among other things, that the acidic portion of the groundwater plume be pumped until at least 2035. This and any additional acidic water that is recovered will be handled and treated along with ARD from the mine and waste rock disposal areas. Barrier wells installed at the plume's terminus also may also be pumped in perpetuity to contain the sulfate portions of the plume. These activities will probably take place before, during and after closure.

11.0 FUTURE AND ON-GOING RESEARCH IN SUPPORT OF CLOSURE

KUCC has been conducting research in support of reclamation and closure since 1978. Much of this work has focused on long-term management of water resources and on the development and testing of reclamation techniques.

In particular, since 1992 KUCC has developed and tested several revegetation methods for the waste rock and tailings disposal areas. This work has been focused on several technologies including slope reduction techniques, the use of biosolids and other soil amendments, the placement of various types and thicknesses of cap materials, and the planting of mycorrhizae-inoculated seeds and seedlings. These efforts began with test plots and culminated in the slope reduction, capping and revegetation of over 600 acres of low pH waste rock surfaces and additional acres on the existing tailings impoundment. This research will continue in the future, testing new technologies as they become available and existing techniques in new physical and geochemical environments.

There are many other ongoing or planned research projects that are designed to fill some of the data requirements identified in Sections 3.0 through 9.0. These studies include:

Study Description	**Status**
Acidification Potential of the Tailing Impoundments	On-going
Preliminary Waste Rock Acid/Base Accounting Study	On-going
Waste Rock Soil Geochemistry Survey	On-going
Pit-Slope Stability Analysis	On-going
Waste Rock Disposal Area Water Balance	On-going
Treatability Study of the Bingham Groundwater Plume	On-going
Treatability Studies of Leach Water and ARD	On-going
Ecological/Human Health Risk Assessment	On-going
Regional Numeric Groundwater Modeling	On-going
Land Use Master Plan	On-going
Waste Rock Disposal Area Design Studies	On-going
Waste Rock Surface Regrading Assessment	Planned
Precipitation Plant Closure Plan	Planned
Future Waste Rock Acid/Base Accounting Study	Planned
Acidification Potential of Ultimate Pit Walls	Planned
Hydrogeology of Post-closure Pit Lake	Planned
Water Chemistry of Post-Closure Pit Lake	Planned
Long-Term Sustainability Plan	Planned

12.0 REFERENCES

KUCC, 1976, Mining and Reclamation Plan for Permit Number M/035/002, 15 p., (Attached to DOGM permit received October 2, 1978)

KUCC, 1986, Permit Application Package, Phase II - Grinding Plant, Ore Conveyor and Floatation Feed Pipeline, 19 p., (Submitted to DOGM on April 28, 1986 with revisions submitted on July 1, 1986 and December 9, 1986)

KUCC, 1988, Tailings Pond Final Reclamation Plan, 37 p., (Submitted to Utah Air Conservation Committee and DOGM on July 1, 1988)

KUCC, 1988, Reclamation Plan for Kennecott's Pine Canyon Mine and Mill Site, 65 p., prepared for KUCC by JBR Consultants, (Submitted to DOGM on July 5, 1988 with multiple revisions between then and April 1, 1989)

KUCC, 1990, Copperton Concentrator Fourth Mill Line Expansion, Notice of Intention to Amend Mining Operations, 39 p., (Submitted to DOGM on February 9, 1990 with revisions submitted on April 16, 1991)

KUCC, 1994, Tailings Modernization Project, Fugitive Dust Abatement Program, 40 p., (Submitted to Utah DAQ on June 7, 1994)

KUCC, 1994, Notice of Intent to Commence Large Mining Operations, Tailings Modernization Project, North Impoundment Expansion, M/035/015, 28 p., (submitted to DOGM on September 14, 1994 with multiple revisions between then and March 15, 1996)

KUCC, 1997, Final Closure Plan, Groundwater Issues, Kennecott Tailings Impoundment, Groundwater Discharge Permit UGW350011, 26 p., (Submitted to Utah DWQ on September 2, 1997)

KUCC, 1998, 1998 Update on Mining Activities Conducted Under DOGM Permit Number M/035/002, 17 p., (submitted to DOGM on September 30, 1998)

APPENDIX A - 1976 MINING AND RECLAMATION PLAN

MINING APPLICATION

NO. ACT-035-002

DATE: August 9, 1976

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING
1588 WEST NORTH TEMPLE
SALT LAKE CITY, UTAH 84116

MINING AND RECLAMATION PLAN

PREAMBLE

Planning for rehabilitation of an operation mine is always difficult. This difficulty is magnified many times when the expected life of the mine may be decades or even a century. Such is the case of the Bingham Mine. It is not even possible to determine the approximate land uses at the end of the mining operation. For that reason, this rehabilitation plan cannot be as specific as that of other, more short-lived, operations.

However, regardless of the end use of the land, it is the intention of Kennecott to leave the land in a stable and productive condition consistent with location, possible uses, and topography, recognizing that since the mine is open pit in nature that the land itself cannot be restored as it was prior to commencement of mining.

To accomplish these objectives, Kennecott will maintain a program of experimentation and will apply the best available technology toward rehabilitating each piece of land as it moves from mining to other uses. A detailed annual report of reclamation work performed during the preceding year will be developed for review by the Board of Oil, Gas and Mining. These annual reports will be utilized by Kennecott and the Division in jointly establishing reclamation plans for the forthcoming year with the intent of accomplishing the overall objectives.

The following plan represents an attempt to outline some of the possible land uses and describe the steps the company will take to reach the general objectives.

MINING AND RECLAMATION PLAN

A. Applicant - Kennecott Copper Corporation, Utah Copper Division.

B. Type of Operation - Mining and processing for mineral extraction. Mining method and processing facilities are continually modified and updated to meet natural and physical requirements and conditions of market, technology, governmental regulation, economics and other factors. Large scale mining operation has been underway since about 1904. Remaining life of the mining operation will depend upon many things including the likelihood that eventual mineral shortages and improved technology will justify mineral extraction from materials now considered waste. It is, therefore, impossible to predict a terminal point for the mining and processing operations. However, it is not expected that this terminal point will occur within the next 50 years.

The Utah Copper Division operations extend from in and around the Bingham Mine to just beyond the north end of the Oquirrh Mountains near Magna (see CONFIDENTIAL map, Exhibit A). The operation is divided into the following areas which are identified on Exhibit A, shown in schematic arrangement on process diagram Exhibit B, and covered separately herein:

1. Mine
2. Mine Waste Disposal
3. Excess Mine Water Disposal
4. Ore Transfer-Mine to process
5. Ore Processing Facilities
6. Tailing Disposal
7. Excess Process Water Disposal

1. Mine Area

The mine area from which overburden and ore is removed comprises approximately 3100 acres.

Prior to open pit mining which began in 1904, this mountainous area had been a source of timber and was being used for underground mining operations with associated surface facilities, residences, businesses, etc. As open pit mining has expanded, these other used have been discontinued.

Determination of a definite use for the area after mining operations cease is difficult due to many uncertainties involved, but will be determined in light of potential use of the land and the condition of the land after reclamation by means that are technologically and economically practicable. Possibilities include:

Scenic attraction.

Historical landmark.

Other public or private use.

Very little vegetation remains in the mining area because of the considerable volume of material having been displaced. The remaining vegetation consists of grasses, forbs, shrubs, and trees such as aspen, mountain mahogany, Utah juniper and fir. The pH of undisturbed soils ranges from 4.5 to 7.5 as determined by mixing 100 gm of soil with 100 ml of distilled water. Most materials removed from or exposed in the mine are acidic. Surface elevation ranges from approximately 5240 feet to over 7800 feet above sea level.

Underground workings and natural bedrock aquifers have been, and will continue to be, encountered during mining operations. The drainage from these abandoned mines and fault-related aquifers is discharged through a railroad tunnel to supply make up water for leaching operations. At times the water is bypassed by pipeline and canal to a disposal area (see Area 3). Typical analysis of this water is listed below:

pH	4.7	Fe	100 ppm
TDS	2,400 ppm	Cl	70 ppm
SO_4	1,400 ppm	Ca	500 ppm
Al	5 ppm	Cu	4 ppm
Mg	50 ppm		

Experiments are being conducted to determine if this water can be used for irrigation.

Since open pit mining began, over 1,350,000,000 tons of ore and 2,400,000,000 tons of waste have been removed. This is one of the largest mining operations ever undertaken, having produced more copper than any other mine in history. The present excavation is approximately 2-1/4 miles wide and 1/2 mile deep (see photograph Exhibit C). There are now 56 levels or benches in the mine which typify open-pit mining, a feasible and economical system for handling the low grade ore and overburden in vast quantities. Height of the benches ranges between 40 and 50 feet. Material is now being removed from 20 lower benches and from upper benches by truck.

After crushing, the ore will be conveyed out of the pit to a new grinding facility located approximately one mile north of Copperton. Waste will be hauled by truck to the existing waste dumps.

The ore body is in the shape of a plug, or an inverted cone. As the mine progressively develops in depth, all benches must be pushed farther and farther back to gain necessary operating space and assure safety by maintaining a stable slope ranging from 25 1/4 to 29 1/4 from horizontal. Modernization and other technological advances, such as innovative dewatering techniques, will allow maintenance of stable pit slopes as a function of specific rock type and moisture conditions in the various sections of the mine. At the conclusion of mining, pit sides will be stabilized at a slope of 30° to 50° from horizontal as a function of location in the mine.

The mining sequence includes drilling, blasting, loading by shovel and haulage by trucks, waste cars and ore cars. At the present time, approximately 108,000 tons of ore and 380,000 tons of waste are removed during each operating day. Ore is transported by rail to process plants, and waste is deposited in outlying areas of the mine (see Area 2). Equipment size continues to increase through improved materials and technology. Haulage trucks now in use at the mine range in capacity from 65 tons to 150 tons. Shovels range from 6-yard to 25-yard capacity.

It is expected that in the future other mining methods such as underground mining and in-situ extraction may become economically feasible and practiced for recovery of lower lying minerals in the Bingham mine area.

At present, it is not possible to perform any revegetation on active dumps or in the pit as open pit mining progresses because the total area is continually being disturbed. At the conclusion of open pit mining, sides will be stabilized at a slope in the range of 32 1/4 to 37 1/4 from horizontal. It is very unlikely that the pit could be revegetated at that time because most of the exposed surface will be solid rock containing natural sulfide mineralization. Meteoric water and atmosphere will generate acidic conditions from these minerals. The bottom of the pit may eventually fill with water; however, the level can be limited by discharge through one of the available railroad tunnels. Such discharge water would either be processed for mineral extraction and neutralization, impounded, used for other acceptable purposes or otherwise safely disposed of as may be determined in the future by the appropriate regulatory agency.

Surface facilities including buildings, railroad tracks, power lines and poles and equipment will be removed from the mine area when no longer needed in the mining or subsequent operations.

2. Mine Waste Disposal Area

Waste material or overburden removed from the mine is deposited in outlying areas in Bingham Canyon, on the west front of the Oquirrhs and in Butterfield Canyon. Total area comprises approximately 8000 acres. Leaching and precipitation operations are conducted for recovery of minerals from this waste material.

Prior to use for waste disposal, the area ranged in elevation from 5200 feet to 7900 feet above sea level and had been a source of timber, was used for dry farming, grazing, and underground mining with associated facilities, residences, business, etc. These uses have been discontinued as waste material has covered the area. However, some grazing and dry farming continues on low lying perimeter areas.

It is expected that leaching and precipitation operations and possibly other processing methods will be used for mineral extraction from the dumps long after final deposition of mine waste is completed. Some possible ultimate uses of the area may include:

A source of borrow and granular material
Residential, commercial or industrial development
Recreational
Scenic
Other

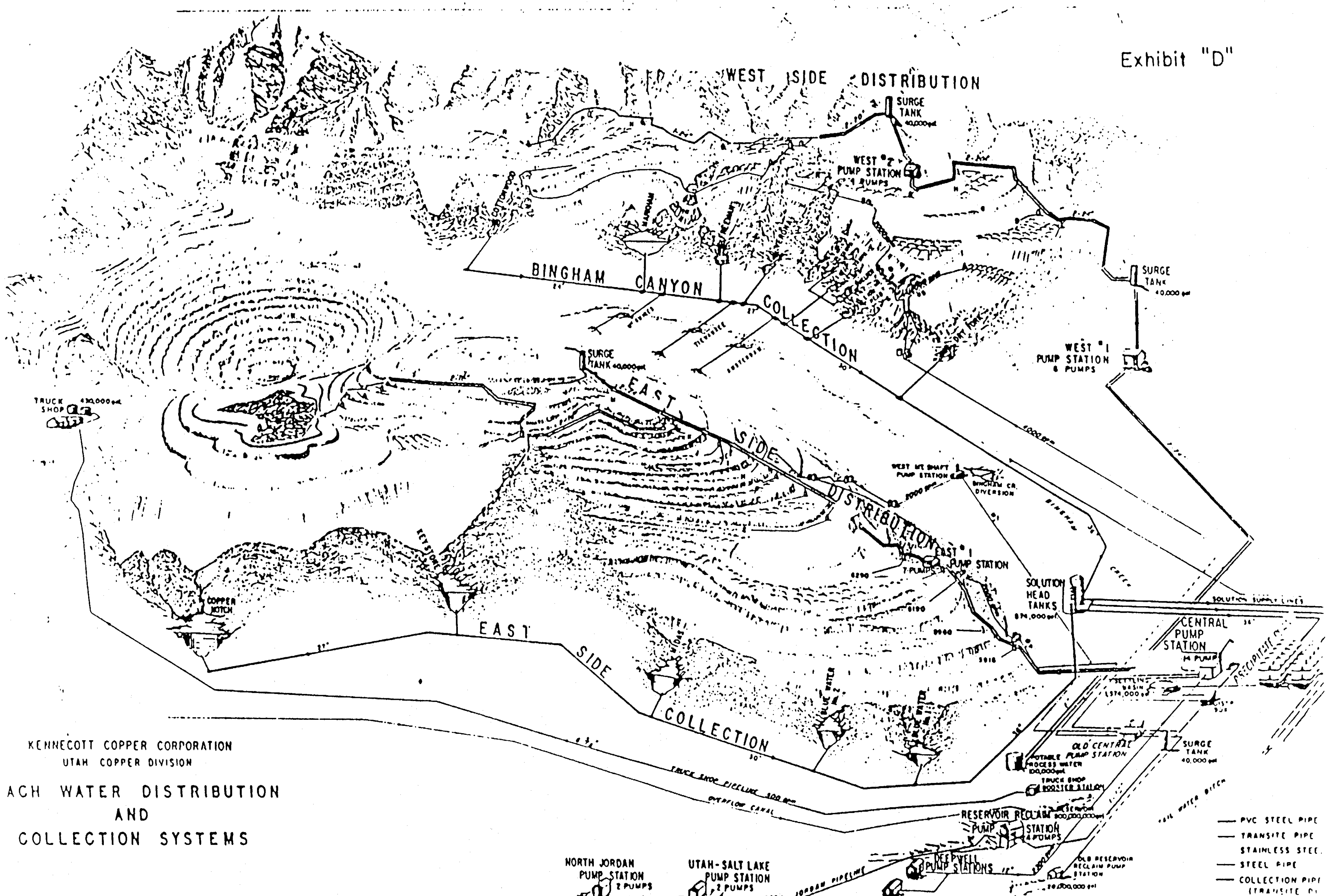
Little or no vegetation exists on areas covered by waste dumps. Vegetation on area that will eventually be covered consists of grasses, forbs, shrubs and trees such as juniper, mountain mahogany and maple. The pH of undisturbed soils ranges from 4.5 to 7.5 as determined by mixing 100 gm of soil and 100 ml of distilled water. Waste dumps tend to become acidic from meteoric water and atmosphere and from the leach solutions (pH 3 - 3.5) that are distributed over the dumps.

The leaching and collection system, including the protection against escape of leach water from waste dumps into lower lying areas, is shown in schematic arrangement on Exhibit D. It consists of reservoirs, pumps and piping to distribute solution on the dumps, pipelines from dams to the precipitation plant and an overflow canal to collect and convey any escaping solution to the reservoir. Leach solution is processed at the precipitation plant for mineral recovery. During extremely wet or high runoff period, excess leach solution may accumulate in the reservoirs and require discharge to the Excess Mine Water Disposal Area (Area 3).

As noted under Area 1, waste dumps presently comprise approximately 2,400,000,000 tons of material and are increasing at the rate of 380,000 tons per day. Waste is transported from the mine by trucks and is dumped over the banks to a natural angle of repose. Rail dumps are terraced at approximately 100 foot levels which progress out generally in a uniform manner. Truck dumps are higher and are extended out at the same level without terracing. Problems in dumps stability have been encountered on some large truck dumps which are generally associated with inadequate foundation material underlying the dumps. Slides have occurred from failure of this underlying or foundation material. However, because these dumps are active, no attempt is needed to stabilize these areas other than monitoring and precautionary systems for safety. Movement detection switches and movement noise detectors have been installed to detect any dump movement prior to failure. These systems will continue to be maintained and improved as mining progresses. In addition, computer models have been developed to simulate conditions in dumps to estimate the position of the dump crest when stability becomes critical. In the future, control points or a survey net may be established to check dump movement and settlement. After dumps become inactive for dumping, other steps will be implemented so that all dumps are left in a safe and stable condition. Techniques to accomplish this may include terracing and hydraulic methods consistent with subsequent use determined at that time. Necessary collection systems will be provided to contain natural seepage in the area. Dikes and ponds will be constructed on the upper levels of dumps to prevent slope wash and possible mud slides.

No major revegetation is planned because the majority of the waste material contains natural sulfide mineralization which becomes acidic when exposed to meteoric waters and the atmosphere. However, in some small areas of the dumps where there is little or no sulfide mineralization, tests are being conducted to determine possible methods and types of vegetation suitable for these areas. These tests include aerial

Exhibit "D"



KENNECOTT COPPER CORPORATION
UTAH COPPER DIVISION

ACH WATER DISTRIBUTION
AND
COLLECTION SYSTEMS

seeding of approximately 20 acres with grasses, forbs and shrubs, and hand planting of a two-acre control area for more detailed study which is being conducted jointly with the U. S. Forest Service. If and when revegetation practices or methods are developed which would make vegetation economically practicable, such practices and methods will be employed on the dumps. When no longer needed in the mining, mineral extraction or subsequent operations, all surface facilities, including buildings, above ground utilities, railroads, piping and equipment will be removed. Much of this type effort has been accomplished in the past, including demolition of buildings in the city of Bingham Canyon, removal of trackage from old rail dumps and removal of bridges in Carr Fork and other demolition and clean up work. Appropriate revegetation of these areas will take place.

3. Excess Mine Water Disposal Area

This involves an approximate 2700-acre area upon which excess mine water is transported and contained in ponds for evaporation. Facilities may be installed at a later date for treatment of water prior to disposal.

Prior to use for excess mine water disposal, which commenced in 1935, the land was used for grazing and dry farms. After construction of the Bingham Creek reservoir at the mouth of Bingham Canyon in 1965, discharge to the evaporation pond area was considerably reduced and now required only during extremely wet or high runoff periods. Currently, much of the land is used for dry farming and sand and gravel operations.

Possible future uses of the land when no longer needed in the mining operation may include one or more of the following:

Sand and gravel operations
Farming
Water storage and evaporation
Recreational
Sludge or water disposal by others
Residential, commercial or industrial development
Other

In addition to dry-farm wheat, the area contains natural grasses, forbs and shrubs. The pH of the natural soils ranges from 6.5 to 7.5 as determined by mixing 100 gm of soil and 100 ml of distilled water. Surface elevation ranges from approximately 4675 feet to 5200 feet above sea level.

Residues of evaporation are acidic and contain soluble ions of iron, aluminum, magnesium and sulfate. Depending upon specific source of excess water from mine operation, water analysis will range between the following values:

pH	4.7 - 3.2	Fe	100 - 2,400 ppm
TDS	2,400 - 6,700 ppm	Cl	70 - 180 ppm
SO_4	1,400 - 52,000 ppm	Ca	400 - 500 ppm
Al	5 - 4,600 ppm	Cu	4 - 100 ppm
Mg	50 - 6,300 ppm		

Evaporation ponds are contained and separated by dikes constructed of earth from the area. Dikes are approximately four feet high and twelve feet wide on top. Side slopes are approximately two horizontal to one vertical. Dikes are monitored and maintained to prevent spill of solution.

At such time as area is no longer needed for excess water disposal or other purposes associated with mining operation, stabilization will be accomplished consistent with subsequent use determined at that time. Stabilization will take into account all pertinent factors including surrounding land usage, potential use, and may include removal or covering accumulated salts, treatment with neutralizer, grading and revegetation work. In any event, area will be left in a safe, table condition suitable for future use and without hazard of erosion or surface water accumulation.

Because the area appears better suited for future uses in farming than other vegetative purposes, any revegetation work would most likely be accomplished to suit farming requirements. In the event of farming, or soil stabilization, this would involve testing by standard agricultural analysis (e.g. Utah State Soils Laboratory), application of fertilizer and cultivation. Such crops as wheat, barley, alfalfa, wheatgrass and clover could be raised. irrigation could be considered if sufficient water becomes available.

There will be no changes in the excess mine water disposal area as a result of modernization. Kennecott is conducting an extensive surface water study. The results of this study may change water usage practice. Kennecott is also conducting a detailed five-year study relevant to this area in cooperation with the State of Utah and Salt Lake County. Any recommendations for amendment of this area will be forthcoming after the study is completed.

4. <u>Ore Transfer - Mine to Process Area</u>

From the mine area at Bingham, ore was transported to the processing plants near Magna by railroad cars. Instead, the ore will be conveyed to a grinding plant located one mile north of Copperton. Approximately 37 acres of right-of-way between the mine and grinding plant will be disturbed by the construction of the conveyor. After construction is completed, the right-of-way will be replanted with a mixture of grass seeds. When the conveyor is no longer needed for mining or other activities, the surface structures will be removed. The area will then be returned to the farming and pasture usage currently ongoing on the property.

The existing railroad between the mine and the facilities near Magna will be maintained and will be used for the transport of precipitate copper and general freight.

Land along the railroad is used primarily for dry farming. It may have been previously used for grazing.

When no longer needed in the mining operation, the railroad may be used to serve future industrial or commercial needs. Otherwise, the railroad right-of-way will have potential use for:

Residential, commercial or industrial development
Utility right-of-way
Roadway
Other

In addition to dry farm wheat, the area contains natural grasses, forbs and shrubs. The pH of the soils ranges from 6.5 to 7.5 as determined by mixing 100 gm of soil and 100 ml of distilled water. Surface elevation ranges from approximately 5400 feet to 4500 feet above sea level.

At such time as the railroad is no longer needed in the mining or processing operations or for subsequent use, trackage and surface facilities will be removed and area left in condition suitable for conversion to other use determined at that time. Revegetation will be accomplished if appropriate for the subsequent use when the trackage and surface facilities are removed and the right-of-way has no future use as such.

5. <u>Ore Processing Facilities Area</u>

Over the years ore processing facilities have been added, changed, enlarged and improved to suit needs and conditions. Many more such modifications are expected in the future. Facilities at one time consisted of the Arthur, Magna, and Bonneville concentrators, power plant, railroad car and engine shops, lime plant, foundry and other supporting and related surface structures and utilities. Total land area comprises approximately 1600 acres. Other separated facilities include water supply and distribution systems and maintenance shops. This represents a total additional area of approximately 200 acres.

As modernization takes place, ore will be received via conveyor at a coarse ore stockpile located at a new ore grinding plant north of Copperton. Ore will be reclaimed from beneath the pile and will be ground in semi-autogenous (SAG) mills and ball mills. The ground ore will be gravity slurried, via pipeline, to the existing concentrators for additional processing through the existing facilities.

The grinding plant will be located on a 100-acre site currently under cultivation for wheat. Following construction, the disturbed but undeveloped areas will be replanted. When the grinding plant is no longer needed for mining or other activities, the surface structures will be removed. The area will then be returned to agriculture or will be available for other types of development.

The pipeline corridor will pass through areas used for wheat cultivation, pasturage, railroad right-of-way, manufacturing, and mining. Approximately 210 acres of the corridor will be on land previously undeveloped for mining or manufacturing purposes. After construction is completed, the disturbed areas within the pipeline right-of-way will be replanted with a mixture of grass seeds. When the slurry pipeline is no longer needed for mining or other activities, the surface structures will be removed. The area will be returned to agriculture or will be available for other types of development.

Possible future uses of the area when no longer needed for ore processing may include one or more of the following:

Other industrial or commercial operations
Residential
Other public or private use

Prior to construction of initial process facilities in about 1906, vegetation consisted of natural grasses, forbs and shrubs such as sagebrush, oak, service, mahogany and juniper. Most of this vegetation remains in undisturbed portions of the area. Other vegetation has been added for stabilization and appearance. This includes trees such as Russian Olive and Chinese Elm, and plants such as alfalfa, clover and various grasses. The pH of natural soils ranges from 6.5 to 7.5 as determined by mixing 100 gm of soil and 100 ml of distilled water. Surface elevation ranges from approximately 4200 feet to 5400 feet above sea level.

At such time as the surface facilities, including buildings, utilities, railroads, equipment, etc., are no longer needed for ore processing or related purposes and if not convertible to some other use, they will be razed and/or removed. All hazardous conditions will be eliminated and ground surfaces stabilized and planted using vegetation types natural or subsequently determined to be best suited to the area.

6. Tailings Disposal Area

Tailing produced from the ore concentrators is discharged as a slurry into a 6000-acre tailing pond adjacent to north of the concentrators. The original ground surface which ranged in elevation from 4210 feet to 4340 feet above sea level is believed to have been a sparsely vegetated, highly alkaline soil such as present perimeter areas. Prior to use for trailing disposal, which began about 1916, some limited livestock grazing may have been attempted.

In its terminal condition for deposition, the tailing pond may be considered as a resource. It will contain unrecovered minerals that eventually may justify reprocessing for recovery. Tailing material also has value as fill for land reclamation and construction such as currently used for highway embankment work. Studies have demonstrated that mixing tailing material with alkali soils enhances capability of sustaining a wide range of vegetation. Considerable areas of Western Utah and Nevada may be reclaimed for agricultural and other purposes by this material.

When no longer needed for foregoing purposes, the tailing disposal area will have potential use for one or more of the following:

Farming
Residential, commercial or industrial development
Recreational
Scenic Attraction
Other

Natural vegetation in the area includes salt grass, wire swamp grass, cattails and salt bush. The pH of the natural soils ranges from 8.5 to 9.0 as determined by mixing 100 gm of soil and 100 ml of distilled water. High clay content of the soil, close proximity to Great Salt Lake, and poor drainage would have contributed to the highly alkaline condition.

The tailing pond is a continually rising area (currently rising at about 3-1/2 feet per year) and is contained by a dike which extends completely around its perimeter. This dike must also be continually raised and be maintained in a stable condition. Initially, dike fill was rock waste from the mine; later fill hauled from areas adjacent to the concentrator plants was used; and more recently, dike build up is being accomplished by relocation of previously placed dike fill material by drag line. This is followed by sealing of the pond side of the dike with a berm of coarse tailing distributed by a perimeter pumping system. To obtain adequate dike stability, the outside of the dike is maintained at 5 to 1 slope as recommended by consultants on slope stability. Periodic inspections are conducted by consultants to assure long-range stability of the system. Present elevation of the pond surface averages approximately 4345 feet above sea level. Dewatering of the tailing pond is by means of two buoy-supported siphon lines which remove clear water, most of which is reclaimed as concentrator process water.

The area near the top of the dike which is subject to being disturbed in the subsequent dike build up, and roads on the dike, are stabilized and will be stabilized to prevent wind erosion. Farther down the outside slope where the surface is permanent, revegetation is practiced. Current plantings include several plant and tree species along the dike slopes. Success has been achieved with Japanese millet, rye, yellow sweet clover, wheatgrass, brome, range alfalfa and vetch plants, and Russian olive, larch and elm trees. Because of the continually rising tailing deposition, permanent stabilization or revegetation of the pond surface is not possible as long as operation continues. However, wind erosion control is and will be practiced. About 90% of the pond surface is kept moist at all times by the natural meandering of the tailing stream discharged into the pond. The remaining areas are treated by several different methods to stabilize the surface. Where possible, the surface is wetted by tailing distribution lines installed for this purpose. If this is not feasible, and the dry areas are accessible to land vehicles, the surface is treated with stabilizing agents.

If not accessible by land vehicles, dry areas are treated by application of a polymer product with aircraft. Use of fast growing grasses is also being investigated for wind erosion control.

Based upon current operating rates and practices, by the year 2025, the tailing pond surface will be reduced to approximately 3,000 acres and the average elevation will be approximately 4560 feet above sea level.

When no longer needed for tailing deposition, mineral recovery or material source, grading and revegetation of dike slopes not already done will be completed. Drainage will not be a problem. As noted previously, the outer surface of the dike will have an average 5 to 1 slope. The pond surface will have, or will be graded to, a natural slope which will be more than adequate for drainage needs, considering that this is a region of low precipitation and the surface can adequately absorb normal precipitation.

Revegetation is also receiving consideration by Kennecott and other mining companies for stabilization and subsequent reclamation of inactive tailing pond surfaces. To this end, test work is being conducted to ascertain which species of vegetation are suitable, and procedures required to obtain adequate vegetation growth. Planting Japanese millet at the rate of 10 to 15 pounds per acre with fertilizer may be a means of vegetating the tailing pond surface after deposition is completed and to a limited extent during the deposition process. The surface of the tailing pond will be stabilized using the most practicable technology available upon the termination of the deposition of the tailing.

7. <u>Excess Process Water Disposal Area</u>

This comprises a treatment plant, sludge disposal area, canals and diversion facilities now existing, as well as possible additional treatment facilities, water storage and evaporation ponds and other facilities that may be required in the future. It involves perimeter areas around the tailing disposal area (Area 6) comprising a total of approximately 1000 acres. Any excess water is discharged under the provisions of NPDES Permit UT-0000051. The discharge criteria may be modified in the future as a result of the surface water study cited in Section 3.

Most of the area remains in a natural state and may have been used for very limited grazing prior to the early 1900's.

Possible future uses of the area when no longer needed for water treatment and disposal may include one or more of the following:

- Other industrial or commercial operations
- Residential development
- Other public or private use

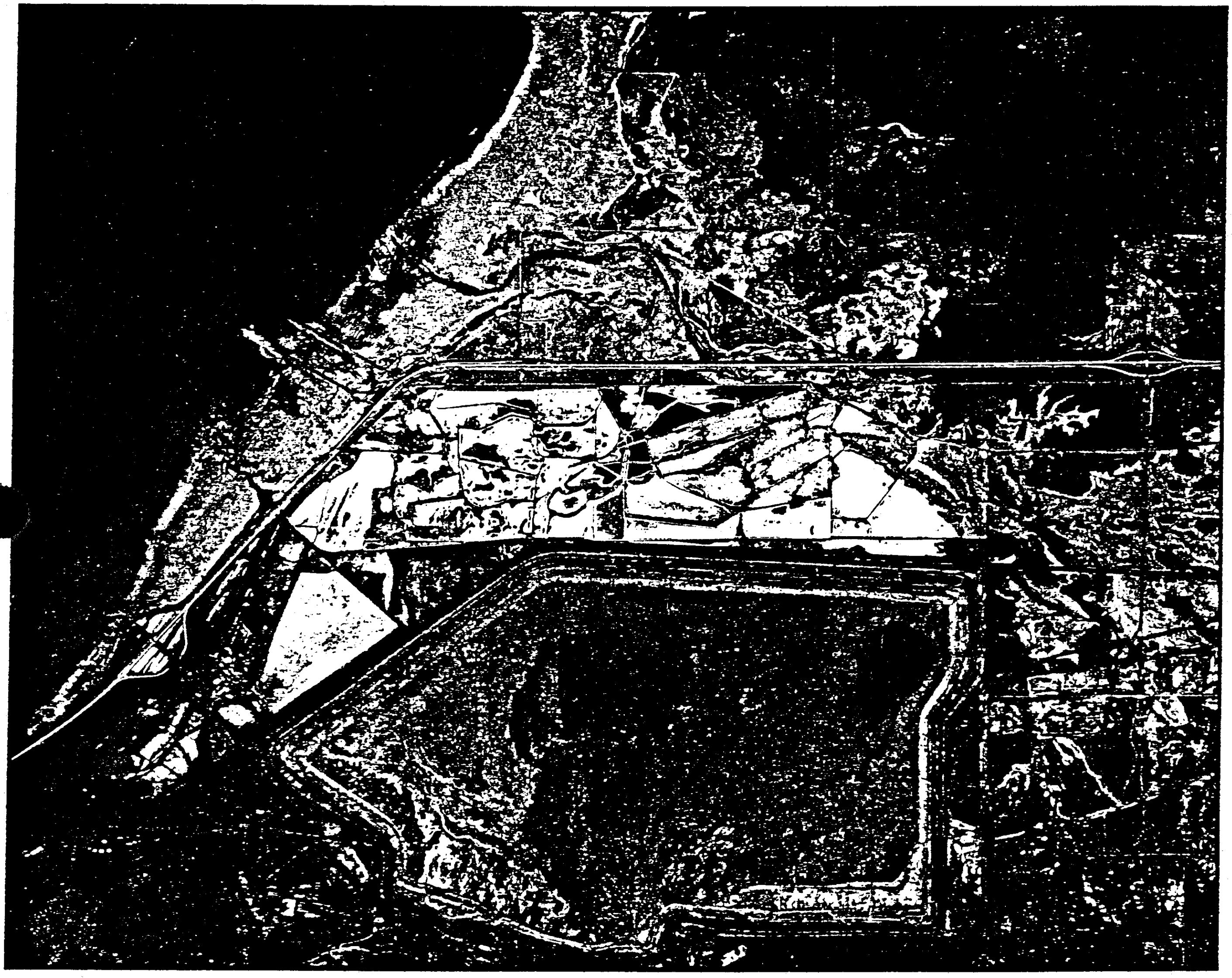
Natural vegetation in the areas includes salt grass, wire swamp grass, cattails and salt bush. The pH of the natural soils ranges from 8.5 to 9.0 as determined by mixing 100 gm of soil and 100 ml of distilled water. The area is comparable to the original ground surface of the tailing disposal area. Surface elevation ranges from 4210 feet to 4300 feet above sea level.

Canals have been constructed around the tailing pond area to convey natural flows and drainage and excess water from tailing pond and treatment plant to the Great Salt Lake. Sludge from the treatment plant is deposited in a low diked area.

At such time as the surface facilities including treatment plant, piping and utilities are no longer needed, and if not convertible to some other use, they will be razed and/or removed. Sludge ponds, evaporation ponds and possible other areas will likewise be left in condition suitable for conversion to other use determined at that time. This may involve filling or covering with tailing and other stabilization and revegetation work comparable to that designated for the tailing disposal area. Canals will most likely be left indefinitely for conveyance of natural surface flows and drainage to Great Salt Lake.

APPENDIX B - TAILINGS MODERNIZATION PROJECT
FUGITIVE DUST ABATEMENT PROGRAM
(PAGES ADDRESSING THE EXISTING IMPOUNDMENT ONLY)

TAILINGS MODERNIZATION PROJECT
FUGITIVE DUST ABATEMENT PROGRAM



Kennecott Utah Copper

Fugitive dust emissions from the constructed dikes will be minimized by periodic application of water and dust suppressants and seeding of slopes.

Placement of tailings distribution pipelines and tailings management facilities for operation of the North Impoundment are not anticipated to be a potentially significant source of dust. Potential fugitive dust emissions will be minimized by periodic application of water in work areas. North Impoundment construction is scheduled for completion in 1998 with use of the North Impoundment scheduled to commence in late 1998 or early 1999.

Existing Tailings Impoundment Transition Construction - 1997-2004.

Construction pertaining to the transition off the existing Tailings Impoundment will involve phased revegetation coordinated with downsizing of the peripheral discharge system. This transition is described below.

Revegetation plan. The revegetation goal is to establish a self-sustaining vegetative cover for long-term dust control, stability, and wildlife habitat. Kennecott conducts an ongoing revegetation program to vegetate the exterior side slopes and stepback dikes of the existing Tailings Impoundment. This program has been in operation for many years, and has produced a vigorous community of grasses, forbs, shrubs, and trees.

Because the top surface of the existing Tailings Impoundment is large, the revegetation plan calls for subdivision of the surface into smaller, more manageable areas. These areas will be revegetated in a systematic, sequential manner, while tailings continue to be deposited onto the unrevegetated beach areas to control dust. Revegetation of the top of the impoundment will begin by building the first of a series of approximately 6 to 10 foot-high main revegetation dikes to separate the area to be revegetated from operational areas and to provide access across the impoundment surface. Main revegetation dikes and revegetation areas are shown on Figure 2.

Revegetation is anticipated to begin in 1997 and continue for five to ten years. In Figure 2, the roman numerals indicate the revegetation sequence for the areas. Revegetation will begin in the western portion of the impoundment and proceed towards the decant pond in the northeast corner. This will allow adequate time for the decant pond, which contains saturated slimes, to consolidate prior to revegetation.

While the revegetation dikes are constructed to isolate each revegetation area, the tailings spigotting or peripheral discharge system will continue to operate within the revegetation area. The main revegetation dikes have been located to take maximum advantage of the surface wetting provided by the existing peripheral spigotting system. Also, the design of the dike system, shown on Figure 2, was closely coordinated with the operation of the cyclone station so that the overflow produced by the cyclone operations can be spigotted off the main revegetation dikes to supplement the peripheral spigotting system.

Prior to planting, the sections of the spigotting system in the revegetation area will be sequentially shut off and the revegetation area will be planted using direct seeding. In areas with poor trafficability, smaller revegetation dikes will be built out from the main dike or a low ground pressure crawler type tractor (commonly referred to as a "swamp taxi") will be used to allow access for hydroseeding equipment. A tackifier may be applied if planting would not occur promptly.

Typically, completion of revegetation dikes, shutting off of spigot sections, and planting will be carried out in the late fall, winter, or spring, since germination and establishment of a vegetative crop are more

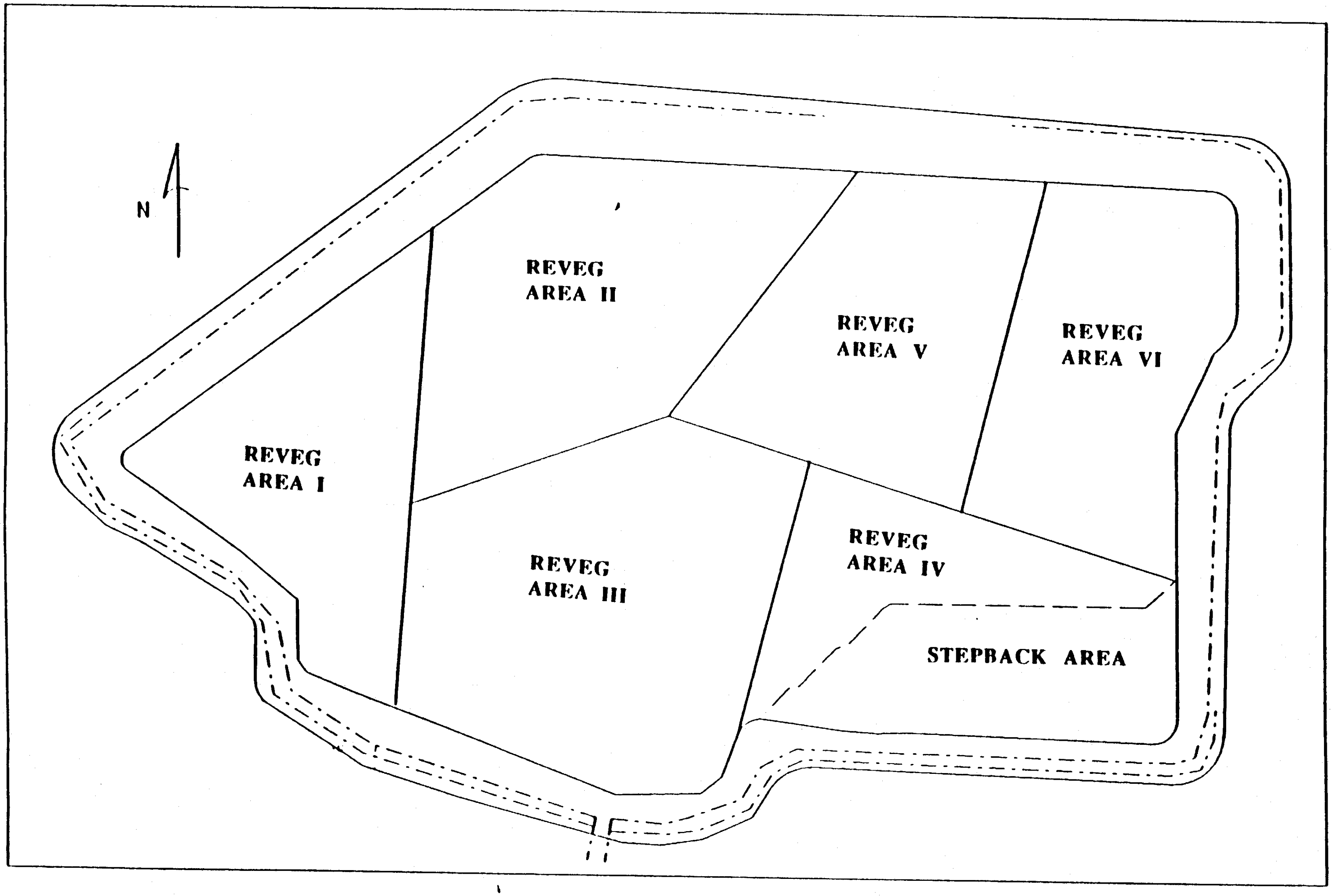


FIGURE 2

REVEGETATION PLAN FOR EXISTING IMPOUNDMENT successful when planting is done to take advantage of winter and spring moisture. Furthermore, frozen ground helps to control fugitive dust, allows the equipment a wider range of operation, and provides the newly planted seeds with moisture from winter snows.

The revegetation steps and seed mixes to be used to establish vegetation will be those that have been successful to date on Kennecott's existing Tailings Impoundment. Fast growing cereal rye grasses will be planted initially with subsequent planting of nitrogen fixing species. Establishment of a vegetative cover will provide long-term dust control.

Table 1 estimates operational, beach, revegetated, and other acreages, by year, for both the existing Tailings Impoundment and the North Impoundment. As indicated in the table, the existing Tailings Impoundment had a beach area of approximately 4,252 acres in 1988 when the existing peripheral discharge system became operational and effective in controlling fugitive dust emissions. The transition was designed to minimize the combined Existing and North Impoundment beach and embankment areas. The combined beach and embankment areas must fluctuate during the transition years due to construction constraints; however, this acreage will never exceed the 1988 acreage on the Existing Impoundment. To control fugitive dust during the transition to the North Impoundment, tailings will be spigotted through the peripheral discharge system to the unrevegetated areas on the Existing Impoundment. North Impoundment construction activities will be accompanied by control measures described in this Program.

Transitional usage of peripheral discharge system on existing Tailings Impoundment. As revegetation progresses from west to east, unused portions of the existing peripheral spigotting system in the western side of the existing impoundment will be relocated to the main revegetation dikes so that wetting of the entire unrevegetated surface of the impoundment will continue. After tailings storage has shifted to the North Impoundment in 1999, the peripheral spigotting system will continue to wet all unrevegetated surfaces of the existing Tailings Impoundment. Thus, Kennecott will continue to use the peripheral discharge system for fugitive dust control on the existing Tailings Impoundment during the transition.

TABLE 1

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ANNUAL SUMMARY OF OPERATIONAL TAILNGS AND REVEGETATED AREAS

Acreage Presented Below Is Limited To The Top Surface of Impoundment

All Figures Are In Acres And Are Approximate, Unless Otherwise Noted

Info.	EXISTING IMPOUNDMENT							NORTH IMPOUNDMENT						TOTAL
As Of End Of:	(1) Total Surface Area (a)	(2) Revegetated Area (b)	(3) Revegetated Area As % Of Total Surface Area ((2/1) x 100%)	(4) Operational Area (1-2)	(5) Decant Pond Area	(6) Active Revegetation Area	(7) Beach Area (4-(5+6))	(8) Embankment Top Surface & Berm Area	(9) Inside Embankment (Includes gypsum tailings)	(10) Gypsum Tailings Impoundment	(11) Decant Pond Area	(12) Beach Area (9-(10+11))	(13) Beach + Embankment Area (8+12)	(14) Combined Beach & Embankment Areas (7+13)
1918	5,700						N/A							5,700
1988	4,553	0	0	4,553	301		4,252			322				4,252
1989	4,481	0	0	4,481	301		4,180			322				4,180
1990	4,409	0	0	4,409	301		4,108			322				4,108
1991	4,337	0	0	4,337	301	147	3,889			322				3,889
1992	4,265	147	3	4,118	301	38	3,779			322				3,779
1993	4,193	185	4	4,008	301		3,707			322				3,707
1994	4,121	185	4	3,936	301	30	3,605			322				3,605
1995	4,049	215	5	3,834	301		3,533	0		322			0	3,533
1996	3,977	215	5	3,762	301		3,461	271	0	322			271	3,732
1997	3,905	215	6	3,690	301		3,389	543	0	322	0		543	3,932
1998	3,905	215	6	3,690	301	558	2,831	543	0	322	1,154	N/A	543	3,374
1999	3,905	773	20	3,132	301	736	2,095	594	2,609	322	1,085	1,202	1,796	3,891
2000	3,905	1,509	39	2,396	301	888	1,207	563	2,630	322	1,017	1,291	1,854	3,061
2001	3,905	2,398	61	1,508	301	322	884	532	2,651	0	1,017	1,634	2,166	3,050
2002	3,905	2,720	70	1,185	0	598	588	501	2,672	0	1,017	1,655	2,156	2,744
2003	3,905	3,317	85	588	0	588	0	470	2,693	0	1,017	1,676	2,146	2,146
2004	3,905	3,905	100	0	0			612	2,714	0	1,017	1,697	2,309	2,309
2005	3,905	3,905	100	0	0			581	2,735	0	1,017	1,718	2,299	2,299
2006	3,905	3,905	100	0	0			550	2,756	0	1,017	1,739	2,289	2,289
2007	3,905	3,905	100	0	0			519	2,777	0	1,017	1,760	2,279	2,279

(a) Operational Areas - Existing Impoundment based on May 1993 mapping and a 72 acre per year shrinking of impoundment area due to raising of the impoundment 1988 to 1996.
Areas based on May 1993 mapping of Site.
(b) Includes Southeast corner Stepback and areas planted during transition.

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APPENDIX C - FINAL CLOSURE PLAN, GROUND WATER ISSUES
KENNECOTT TAILINGS IMPOUNDMENT
(WITHOUT PLATES)

FINAL CLOSURE PLAN

GROUND WATER ISSUES

KENNECOTT TAILINGS IMPOUNDMENT

GROUND WATER DISCHARGE PERMIT UGW350011

Prepared by:

Kennecott Utah Copper
September 1997

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INTRODUCTION

The Division of Water Quality issued Kennecott Utah Copper a ground water discharge permit for the Tailings Impoundment expansion which requires the submission of a closure plan for the Tailings Impoundment. The purpose of this document is to provide a general description of the closure plan for the Tailings Impoundment and to discuss measures that will be taken prior to and after closure to protect ground water in the area. This document fulfills the requirements of Part I Section K Item 9 of the Ground Water Discharge Permit for the Tailings Impoundment (the Permit), permit number UGW350011.

The Tailings Impoundment is located at the north end of the Oquirrh Mountains, near the edge of the Great Salt Lake (see Figure 1). At closure, the impoundment will consist of two major portions, the existing impoundment and the North Expansion. A general layout of the site showing these two portions of the impoundment, as well as other major features, is provided on Plate 1. A diagram, conceptually illustrating the appearance of the impoundment at final closure is provided in Plate 2. Closure of the impoundment will be completed when the new expansion reaches estimated design capacity of 1.9 billion tons, currently projected at 25 to 30 years. Prior to final closure, portions of the existing impoundment will be closed and reclaimed as the North Expansion is placed into operation.

Closure of both the existing and expanded impoundments will be accomplished by separately diking off large areas of the impoundment. As these areas are diked off, they will be vegetated and reclaimed. The location of these dikes is shown in Plate 3 for the existing impoundment and in Plate 4 for the expanded impoundment. The use of dikes will allow for the isolation and separation of these areas and for the gradual closure of the impoundment.

CLOSURE ISSUES

With respect to the ground water, the following closure issues have been identified and will be addressed within this plan:

- Potential for acidification of the tailings after closure.
- Potential process water discharges to ground water.
- Surface water drainage and discharges.
- Tailings Impoundment water balance.
- Potential changes in the quality of ground water discharged.

Of the issues identified, only the potential for the acidification of the tailings could result in conditions at closure being worse than existing and/or future operating conditions. Data collected to date, however, indicate that there is no significant potential for acidification of the tailings that would result in closure problems with respect to ground water.

ACIDIFICATION POTENTIAL

Tailings deposited in the Tailings Impoundment will remain in the impoundment after closure. Water stored within the tailings will have the same quality as the process water deposited in the tailings. There is a potential that sulfide metals stored within the tailings could oxidize and produce low pH waters capable of leaching metals and other substances from the tailings and alter the quality of the water. Kennecott has conducted a number of investigations directed at evaluating the potential for acidification of the tailings. These investigations include:

- "Acidification Potential of the Kennecott Tailings," Schafer and Associates, and Shepherd Miller, Inc., 1995.
- "1996 Data Summary Report for the Test Fill and Step-Back Area," Schafer and Associates, and Shepherd Miller, Inc., 1997
- "Appendix A Sampling Results, Kennecott Utah Copper, Magna Utah," Shepherd Miller, Inc., 1997
- "1996 Annual Operational Monitoring Report for the Tailings Impoundment Ground Water Discharge Permit UGW350011," Kennecott, 1997.

Results of these investigations have indicated that:

- The net acidification potential of the impoundment is positive, i.e., the oxidation of sulfates in the tailings, as a whole, will not generate acidic conditions. While individual surface layers may generate acidic conditions, these acid waters will be neutralized by the excess neutralization potential found in other (deeper) layers.
- Due to the presence of fine-grained layers within the tailings, the depth of oxygen penetration is very limited, generally less than four to six feet. These layers will remain at or near saturation. Under these conditions, migration of oxygen is greatly reduced due to the low permeability of oxygen under saturated conditions. The lack of oxygen at depth will prevent acidification of deeper tailings and also limits potential acidification of the tailings to the upper surficial tailings cover. Any potential degradation of water quality is, therefore, also limited to the shallow surficial depths within the tailings impoundment.
- The shallow depth of potentially acidified areas, coupled with the horizontal nature of tailings water flow within the tailings (discussed in subsequent sections), will restrict any

potential water quality problems to surface water discharges. Even if acidified tailings waters were to migrate vertically, these waters would be neutralized by the tailings as they passed through. Tailings water quality would not be significantly different from existing tailings water which is generally better than the natural water quality of the ground water in the aquifers below the Tailings Impoundment.

- Based on the characterization of acidification potential of the tailings covering the existing impoundment, approximately 25 to 35 percent of the exposed surficial tailings are expected to generate acidic conditions. The extent and possible impacts of this potential acidification are shown in the older portions of the existing impoundment where the tailings have already been oxidized.

- The final lifts of tailings placed on the existing impoundment will contain higher percentages of neutralizing minerals because these tailings will contain the finer grained overflow fraction of the cycloned tailings in which the neutralizing minerals are present at higher concentrations.

Kennecott will continue to characterize the tailings with respect to their potential to generate acidic conditions and this characterization will continue through closure of the North Expansion. Available data indicate that future conditions for the existing impoundment are likely to improve, and that conditions will be better than those that currently exist.

Due to the cycloned nature of the coarser grained underflow tailings, used to construct the embankment of the expanded tailings impoundment, the potential for acidification of these tailings is somewhat greater than for the existing impoundment. These tailings will be fully characterized prior to closure and provisions have been included in the DOGM bonding requirements to cover the costs for correction of acid conditions in the unlikely event that such conditions were to develop.

POTENTIAL DISCHARGES TO GROUND WATER

Kennecott has conducted a number of studies addressing the potential discharge of tailings water to ground water. These studies include:

- "Ground Water Assessment of the Great Salt Lake Area," Engineering Technologies Associates, Inc., 1992.

- "Regional Hydrogeologic Report for the Great Salt Lake Area," GeoTrans Inc., 1992

- "Regional Geochemical Report for the Great Salt Lake Area," GeoTrans Inc., 1992

- "Hydrogeologic Report for the Great Salt Lake Area," Kennecott, 1992.

- "Tailings Impoundment Liner Alternatives Report, Woodward-Clyde Consultants, 1993.

- "Geotechnical Detailed Design Report, Utah Copper Tailings Modernization," Woodward-Clyde Consultants, 1993.

- "Summary Report Gypstack Characterization," Shepherd Miller, Inc., 1995.

These, along with other investigations, were provided to the Division of Water Quality as part of Kennecott's Ground Water Discharge Permit Application and serve as the basis for issuing the Ground Water Discharge Permit for the Tailings Impoundment. These investigations show that the seepage from the Tailings Impoundment is minimal and will not adversely affect underlying ground water.

The hydraulic conditions existing during the operational phase of the Tailings Impoundment (shown in the cross-section of the Tailings Impoundment in Figure 2), will remain largely unaffected after closure. Changes to hydraulic conditions that will occur during closure are:

- Decreased water levels within the impoundment of approximately 33 feet.

- Increased consumption of water discharged to the impoundment by the vegetative cover that will be established on the closed impoundment.

- Decreasing rates of water recharge into the Tailings Impoundment.

These changes will result in a reduction in the rate at which tailings water is potentially discharged to ground water.

The rate of tailings water seepage through the Tailings Impoundment, for the fully saturated condition, was estimated at 875 gallon per minute (gpm) in the Ground Water Discharge Permit Application. Recent estimates of the elevation of tailings water within the Tailings Impoundment at closure (see the following section on surface water discharges during closure) indicate that the hydraulic heads at the tailings-foundation contact will be reduced by an average of 16%. Because the rate of seepage into the underlying aquifers is proportional to the head above the foundation, seepage from the closed impoundment would be reduced by approximately the same percentage (to approximately 730 gpm). At the predicted rates of seepage for the operational impoundment there will be no significant adverse impacts to the underlying aquifers. Potential impacts will be further reduced during closure.

Ground water monitoring is being conducted during the operational phases of the Tailings Impoundment to ensure that there are no adverse impacts to ground water quality. This monitoring will be continued into closure. However, the quantity and frequency of the monitoring performed can be greatly reduced, particularly with time beyond closure.

SURFACE WATER DISCHARGE

Closure of the Tailings Impoundment will modify both surface water and tailings water drainage. Under operational conditions, process water is circulated through the impoundment and used in the process or is discharged at UPDES Outfalls. Storm water falling in and on the impoundment, as well as tailings water seepage, is included in the process water system.

Upon closure, the tailings surface water drainage will be modified such that only storm water falling on the edges of the impoundment will be discharged to the surface water system. Storm water falling on the impoundment will be retained in the impoundment. The toe collection ditch will be used to route all storm and tailings seep water to the UPDES Outfall 007 where it will be discharged to lower Lee Creek. A map showing the site surface water drainage after closure is provided on Plate 5.

The Tailings Impoundment is located in an area of ground water discharge and, therefore, storm waters from the Tailings Impoundment will not infiltrate into the ground water. It is anticipated that this will continue to be an area of ground water discharge after closure, however, even if the direction of recharge were reversed, little surface water would be able to infiltrate into the ground water due to the low permeability of the shallow sediments and the lack of significant heads to drive the infiltration of surface water.

Tailings Seepage

After closure, the only tailings water discharged from the impoundment will be seepage draining from the embankment of the existing impoundment from the blanket drain constructed beneath the embankment of the North Expansion. Although the rate of seepage discharge will diminish once tailings inflows stop, seepage from the Tailings Impoundment will continue indefinitely. Large decreases in the rate of seepage are anticipated to result from the termination of embankment construction during the first year after closure. Beyond the first year, seepage rates will continue to decrease, although more slowly. Additional information concerning the rates of tailings water discharge is provided in the tailings water balance section.

Storm Water Discharge

Precipitation falling on interior portions of the Tailings Impoundment will not be drained as surface water. Dikes, constructed to contain the deposition of the final tailings lift as each section is closed, will be constructed at an elevation high enough to prevent any potential run-off of the interior portions of the closed areas. Collected water will pond internally and either be absorbed or will evaporate. Precipitation falling on the Tailings Impoundment embankment will be drained to the toe collection ditch surrounding the impoundment.

Ground Water Discharge

Under current and anticipated future ground water conditions at closure, it is presumed that ground water will continue to discharge into the toe collection ditch, other ditches, and water conveyance structures surrounding the Tailings Impoundment. These ditches are constructed as topographic lows in this area, therefore, ground water will naturally flow into these structures. The anticipated ground water elevation and direction of flow after closure are shown on Plates 6 and 7 for the Shallow and Principal aquifers respectively. The actual rate of ground water discharge into these ditches is, however, quite small, likely only a few tens of gallons per minute, as a result of the low vertical hydraulic conductivity of the Shallow Aquifer. Water discharged in the toe collection ditch will include tailings water that has entered the shallow aquifer beneath the Tailings Impoundment and then traveled horizontally until discharged.

Because of the poor natural quality of the Shallow and Principal aquifer, it is unlikely that ground water resources in this area will ever be developed sufficiently to change the direction of flow from the toe collection ditch into the underlying aquifers. Even were such a condition to develop, it is unlikely that a significant amount of seepage would occur due to the limited gradients that could be developed and the low vertical hydraulic conductivity of the Shallow Aquifer.

TAILING WATER SEEPAGE

The rate of seepage of tailings water from the existing impoundment has been estimated at 2,500 gpm for existing conditions (Mass Balance Report, 1995, prepared by Shepard Miller Inc.). Seepage from the existing impoundment will be reduced as the expanded impoundment is brought into operation, but much of this reduction will be replaced by seepage from the expanded impoundment. In order to evaluate the potential impacts of this seepage on surface water flows from the impoundment after closure, estimates of seepage rates after closure have been made utilizing two differing approaches, a water balance and numerical hydraulic modeling of the closed impoundment.

WATER BALANCE

A detailed water balance for the Tailings Impoundment after closure was presented in the report "Acidification Potential of the Kennecott Tailings." A copy of this water balance is provided in Appendix A. This model assumed that run-off would be discharged from the impoundment and that any water remaining after accounting for evaporation, evapotranspiration, and run-off would be discharged as seepage. The results of this water balance indicated that, after closure, the volume of water received as precipitation was only slightly (5%) greater than the volume of water lost from the impoundment due to evaporation and evapotranspiration. This model, however, assumed that all areas of the impoundment would have run-off and that the run-off would be discharged from the impoundment. Since only a very limited portion of the impoundment will be allowed to drain as surface water, the volume assumed to be lost as surface water will, instead, be lost as evaporation and seepage. This model was recently updated by its authors (Schafer and Associates) to include the effects of surface water run-off and to include some better estimates of soil parameters. These revisions and their impacts on the original estimates are discussed in Appendix B. Table 1 summarizes the results of these revisions and indicate an estimated seepage rate of 330 gpm.

These calculations assume that there will be no change in the volume of water stored in the impoundment. This is incorrect, as water will be released from storage in the impoundment and, therefore, the initial seepage rate will be higher than predicted by this approach. Once the deposition of new tailings is stopped, the water stored within the tailings will start to drain, both as lateral discharge to surface water and as seepage to ground water. Initially, the rate of discharge will be the same as current rates of discharge and will decline rapidly as time passes beyond closure. The seepage rates at closure is estimated to be:

• Discharge to ground water at the time of transition off of the Existing Impoundment.*	620 gpm
• Discharge to ground water from the North Expansion at closure *	206 gpm
• Seepage to surface water at the time of transition off of the Existing Impoundment *	2500 gpm
• Seepage to surface water from the North Expansion at closure**	2700 gpm
Total	6026 gpm

* Estimate obtained from the "Final Environmental Impact Statement for the Kennecott Tailings Modernization"

** Estimate obtained from the report "Mass Balance Report" prepared by Shepard Miller, Inc., 1995

The rate of seepage estimated for the existing impoundment is high because much of the water stored will have drained off by the time the North Expansion is closed. Given that the seepage rate will be the highest at closure, the estimate of 6026 gpm is the maximum seepage rate that could occur. The estimate of 330 gpm, obtained from the post closure water balance, is the lowest rate obtained using these water balance approaches. Hydraulic calculations, discussed in the next section, indicate a potentially lower rate of 190 gpm obtained using the EPA's Hydrologic Evaluation of Landfill Performance (HELP3) model.

The volume of water stored within the combined impoundments at closure will be approximately 130 billion gallons. Using the initial seepage rates as the maximum rate, the volume of water stored in the Tailings Impoundment would take a minimum of 40 years to drain. The actual rate will be much lower since the rate of seepage will decline rapidly in the period immediately after closure. Ground water modeling, discussed in the next section, indicates that most of this drainage will occur within 100 years and that a near steady state condition will develop by that time.

HYDRAULIC MODEL OF TAILINGS WATER SEEPAGE

Schafer and Associates numerically modeled the hydrology of the Tailings Impoundment using the hydraulic properties of the tailings coupled with reasonable assumptions for the water inputs into the impoundment. The results of their modeling are provided in Appendix A and indicate a seepage rate of 4,391 gpm at closure, decreasing to 220 gpm once steady state conditions are achieved.

The soil properties, assumed by the model provided in Table 2, are based on data collected during the design of the tailings expansion that characterize the nature of the tailings and underlying materials. Model boundaries and the configuration of the model is provided in Figure 3. This figure also shows the simulated water level after closure of the impoundment which is approximately 25 feet lower than the operational water level. A comparison of this seepage estimate with those calculated using a mass balance approach is provided in Table 3. Figure 4 shows the change in predicted seepage rates as a function of time. It is anticipated that over one hundred years will be required for the rate of seepage to reach a steady state equilibrium.

The predicted steady state seepage rate of 220 gpm, does not include an estimated 826 gpm (as estimated in the Ground Water Discharge Permit Application) of seepage which is lost through the impoundment foundation directly to ground water. The seepage rate through the impoundment foundation will decrease gradually until upward gradients in the shallow aquifer return and the net seepage into the underlying aquifer goes to zero. This is anticipated to take hundreds, to thousands, of years.

CLOSURE PLAN

This document provides the major elements of the closure plan as related to ground water issues. Additional details concerning the general closure of the impoundment are provided in the document "Tailings Modernization Project DOGM Consolidated App'n" submitted to the Division of Oil Gas and Mining (DOGM) on March 15,1996.

The Tailings Impoundment will be closed in two phases. The first phase will be the transition of operations from the existing impoundment as the North Expansion becomes available for tailings storage, with the second phase being the subsequent closure of the North Expansion at the end of its useful life.

TRANSITION PLAN FOR THE EXISTING IMPOUNDMENT

Transition of tailings storage activities from the existing impoundment will include the following activities:

- Removal of unnecessary facilities.

- Reclamation and vegetative stabilization of disturbed areas.

- Vegetation of the embankment and surface of the impoundment.

- Monitoring.

Reclamation and vegetation of the existing impoundment will be achieved in stages as the transition is made between the existing impoundment and the North Expansion. Because the top surface of the existing impoundment is large, this area will be subdivided into a number of smaller areas (shown on Plates 3 and 4), while tailings continue to be deposited onto unreclaimed areas. This procedure is designed to minimize fugitive dust emissions to the air. Reclamation is anticipated to begin in the western portion of the impoundment and proceed towards the decant pond in the northeast corner over a period of several-years. Thus, portions of the existing impoundment will be reclaimed and removed from use as the North Expansion is brought on-line. Closure of the top of the existing impoundment is anticipated to be complete by the year 2005. Structures used for operation of the North Expansion, located on the sides of the existing impoundment, will be removed when the closure of the final phase of the North Expansion is completed.

CLOSURE PLAN FOR THE NORTH EXPANSION

Closure of the expanded impoundment will involve the removal of remaining above-ground, man-made, structures from the existing and expanded portions of the impoundment. Structures such as the toe ditch and the 007 Outfall will remain to control drainage from the impoundment. Reclamation of the impoundment will be performed in accordance with a reclamation plan approved by DOGM. Techniques employed will be similar to those used to transition operations from the existing impoundment, with updated technology as appropriate. As with the transition from the existing impoundment, the surface of the impoundment will be subdivided into a number of smaller areas that will be reclaimed in a systematic, sequential manner, while tailings continue to be deposited onto operational areas. The locations of these areas are shown on Plate 4.

Reclamation

Reclamation of the Tailings Impoundment will occur during operation of the impoundment and at closure. The main reclamation objectives during construction and operation are to:

- Vegetatively stabilize all areas disturbed by construction activities as soon as possible after the activity is completed,

- Reclaim the rises of the exterior slopes of the impoundment on a seasonal basis, and

- Establish a vegetative community suited to wildlife habitat.

Primary objectives for final reclamation are to:

- Reclaim the top surface of the impoundment for long-term fugitive dust and erosion control, with minimal maintenance requirements,
- Establish a vegetative community best suited to wildlife habitat, and
- Provide for the long-term vegetative stabilization of the impoundment.

Kennecott's ongoing reclamation program has produced a vigorous community of grasses, forbs, shrubs, and trees on the Tailings Impoundment which is used as a habitat by a variety of wildlife. This proven approach will be the basis for reclamation of the impoundments at closure. Specific methods used to achieve these objectives are detailed in the document "Tailings Modernization Project DOGM Consolidated App'n."

Storm Water

The remaining storm water and tailings seepage water will be routed through the toe ditch and eventually discharged to Lee Creek. The toe drain will be left in place after closure to facilitate drainage of surface and seepage water from the tailings embankment to the C-7 ditch, Lee Creek, and ultimately to the Great Salt Lake. The discharge of this water from the impoundment will occur at the 007 Outfall and will be in accordance with the regulatory requirements and limits set forth at that time.

Ground Water

Neither the quality nor the quantity of potential discharges to ground water will change significantly upon closure. The elevation of the saturated tailings water surface will begin to decline once the deposition of new tailings water is stopped. However, the rate of decline in the saturated tailings water surface will be so small that it will not significantly affect the rate of tailings water seepage through the foundation surface. Since no additional water will be applied to the surface of the impoundment, the waters potentially discharged are those stored during tailings deposition and precipitation onto the impoundment surface. The quality of this water will be the same after closure as is currently being discharged.

MONITORING DURING CLOSURE

Monitoring of the Tailings Impoundment will continue, as specified in the Permit for operating conditions, as sections of the impoundment surfaces are taken out of service. However, additional samples of the tailings will be collected as the final lift (last three feet) of tailings is placed in the section being closed. These samples will be "grab" samples collected from the tailings spigots located in the area being closed. The sampling rate will be approximately one sample per each 200 acres closed. These samples will be analyzed to determine their acid generating potential. If these analyses indicate that a significant acid generating condition is likely to exist within the surfical tailings, remedial actions will be considered and, if necessary, implemented. Evaluation of the potential for developing significant acid generating conditions will be based on our past history in meeting reclamation goals given similar test results. Tailings samples will also be collected from the surface of closed sections of the impoundment after the final lift of tailings is placed, but prior to vegetation. These samples will also be collected at a rate of one sample per each 200 acres closed. These samples will be analyzed to determine their acid generating potential. Sampling and analyses will be as specified in Appendix A of the Permit.

POST-CLOSURE MONITORING

A detailed closure monitoring plan will be submitted to the DWQ six months prior to closure of the North Expansion. This monitoring plan will specify the actual compliance and operational monitoring required after closure. After closure, the closure monitoring plan will be reviewed and, where necessary, revised every five years and submitted with each Ground Water Discharge Permit renewal application. The following sections outline the major elements of the anticipated Post-Closure Monitoring plan.

MONITOR POINTS

Post-closure monitoring will consist of ground, surface, and tailings water monitoring and will be implemented upon closure of the North Expansion. The location of each monitoring point is shown on Plate 8.

Ground Water

The network of ground water monitoring wells used for operational monitoring, identified in Table 4 and shown on Plate 8, will be used for the post-closure monitoring. If these monitoring wells are damaged, contain more than two feet of sediment, or have a substantially decreased yield, they will be redeveloped or replaced. Samples collected from these wells will be analyzed for the parameters as specified for operational monitoring in the Permit (see Table 5). The analytical methods used will be those specified in Table 6. Analytical results will be evaluated as specified in Part I Section H of the Permit to determine whether ground water quality has been affected by the impoundments.

These wells will be sampled semi-annually for five years after closure. If, after five years, no statistically evident degradation of the water quality is measured, the sampling frequency will be reduced to annually for the next five years. Ten years after closure, the results of the monitoring data collected during closure will be reviewed and the number of wells required for monitoring and frequency of sampling reviewed. Based on the results of this review, the monitoring program will be revised. It is anticipated that the number of wells monitored and the frequency of monitoring will be reduced to once every five years. Ground water monitoring of the impoundment will end 30 years after closure, unless conditions warrant otherwise. Should the post-closure ground water monitoring data indicate that additional monitoring is not necessary, Kennecott will petition the Executive Secretary to discontinue post-closure monitoring.

Monitoring data collected during the post-closure period will be reviewed to ensure that none of the compliance limits specified in the permit are exceeded at the time of closure. Should any compliance limits be exceeded, the well would be immediately resampled. If the resampled data still show exceeded water quality compliance limits, the statistical significance will be evaluated using the methods described in the Statistical Methods For Evaluating Ground Water Monitoring Data for

Hazardous Waste Facilities, Volume 53, No. 196 of the Federal Register, October 11, 1988. If this evaluation indicates the exceedance is statistically significant, the cause will be determined using the procedures outlined in Section R317-6.15 of the Ground Water Quality Protection regulations. If the exceedance is related to the Tailings Impoundment, the need for corrective actions will be evaluated and a Contamination Investigation and a Corrective Action Plan will be prepared and implemented. A compliance/contingency decision schematic is provided in Figure 5.

The analytical methods used in the analysis will be those identified in Table 6. Procedures for installing monitoring wells, collecting and analyzing ground waters, and QA/QC samples are provided in KUC's Ground Water Characterization and Monitoring Plan (1996). This plan will be updated as necessary to reflect post-closure requirements.

Surface Water

Table 7 identifies the surface water sampling points and sampling frequency during the post-closure period. The locations of these sampling points are shown on Plate 8. Surface water monitoring will include the discharge from the toe collection ditch to Lee Creek (the UPDES discharge point 007), sampling point CLC452, located in the Clarification Canal, and three tailings water seeps. The water quality data collected at these points will be used for informational monitoring purposes only. All discharges from the Tailings Impoundment will be required to meet the terms of the UPDES permit in effect at that time.

Surface water samples will be collected using the procedures detailed in Kennecott's "Procedures for Water Quality Sampling." Samples will be analyzed for the list of parameters specified in Table 5, and the methods of analyses used will be those identified in Table 6.

Tailings Water

The interstitial water stored within the Tailings Impoundment will be monitored using monitor wells and lysimeters completed within the tailings. The points to be sampled are listed on Table 8 and their locations are shown on Plate 8. Water quality data collected at these points will be used for informational monitoring purposes only.

Sampling will be conducted as specified in Kennecott's "Procedures for Water Quality Sampling." Samples will be analyzed for the list of parameters specified in Table 5 and the methods of analyses used will be those identified in Table 6.

REPORTING AND NOTIFICATION

Monitoring Reports

KUC will prepare a summary of the post-closure monitoring results. During the first ten years following closure, the report will be submitted by the end of March for the preceding calendar year. After the tenth year, the report will be part of the permit renewal application submitted every five years. Information regarding monitoring well logs and construction details for replacement or new monitoring wells installed will be submitted to the DWQ within 30 days of the completion of the work.

Determination of Compliance

Compliance for monitor wells will be determined as specified by the requirements of Part I Section H of the Permit. Should any compliance problems be encountered, the actions specified in this section would be taken.

Surface water and tailings water monitoring will be conducted for informational purposes only and no compliance conditions are specified.

Table 1

Water Balance at Closure

WATER BALANCE INPUT DATA AND MONTHLY CLIMATIC SUMMARY

	DATE	WATER YR DATE
DATE WHEN SNOW ACCUMULATES	10/01/79	0
DATE WHEN SNOWMELT BEGINS	03/31/80	182
DATE WHEN SNOWMELT ENDS	04/29/80	211

	TOP	SLOPE
WATERSHED AREA (ACRES)	7886.00	1580
UPPER LIMIT SOIL STORAGE (in/ft)	2.4	2.4
LOWER LIMIT SOIL STORAGE (in/ft)	1.2	1.2
SOIL THICKNESS (ft)	1.5	1.5
PERCENT FULL AT BEGIN	51	51
MAXIMUM Ks	0.001	0.001
MAXIMUM DAILY PERC (in)	219.5	219.5
SCS CURVE NUMBER (II)	35	72
SCS CURVE NUMBER (I)	16	53

		PET	CROP	AET	ACTUAL PPT	EFFECT PPT	SNOW
OCTOBER	1	2.62	30	0.30	0.26	0.26	0.00
NOVEMBER	2	2.87	20	1.42	2.49	2.49	0.00
DECEMBER	3	0.58	10	0.31	1.19	1.19	0.00
JANUARY	4	1.19	10	0.40	0.82	0.82	0.00
FEBRUARY	5	1.3	10	0.36	0.38	0.38	0.00
MARCH	6	5.67	30	3.08	1.54	1.54	0.00
APRIL	7	9.98	40	2.65	2.68	2.68	0.00
MAY	8	11.34	40	0.42	0.40	0.40	0.00
JUNE	9	6.5	40	2.50	2.79	2.79	0.00
JULY	10	5.78	40	0.45	0.16	0.16	0.00
AUGUST	11	5.35	40	0.89	0.89	0.89	0.00
SEPTEMBER	12	6.12	40	1.18	1.18	1.18	0.00
ANNUAL TOTAL		59.3		13.95	14.78	14.78	

IMPOUNDMENT INPUT DATA

IMPOUNDMENT THICKNESS (ft)	200
VALUE OF N	1.37
VALUE OF ALPHA	0.059
VALUE OF Ks (cm/s)	0.0000133
RESIDUAL THETA (%)	3.4
MAX THETA (%)	48.0
INITIAL THETA	6.83
FINAL THETA	6.83

WATER BALANCE RESULTS

SOIL WATER BALANCE (in/yr)

	TOP	SLOPE	AVERAGE
RAINFALL	14.78	14.78	14.78
RUNOFF	0.00	0.57	0.10
ET	14.00	13.90	13.98
PERCOLATION	0.81	0.35	0.74
STORAGE	-0.04	-0.04	-0.04
DRAIN LAYER	0.00	0.00	0.00

NET PERCOLATION (FT3)	25,297,535
IMPOUNDMENT STORAGE (FT3)	1,868,045
RUN-ON WS1 (FT3)	0
RUN-ON WS2 (FT3)	0
AVERAGE SEEPAGE (GPM)	333.4
MAXIMUM SEEPAGE (GPM)	337.7

Table 2

Model Input Parameters

Material Type	Saturated Hydraulic Conductivity (cm/second)	Saturated Water Content (cm^3/cm^3)	Residual Water Content (cm^3/cm^3)	Van Genuchten Constants	
				α	n
Whole Tailings	1.3×10^{-5}	0.48	0.034	0.059	1.37
Cycloned Tailings	5×10^{-4}	0.40	0.045	0.124	2.68
Slime Tailings	7×10^{-6}	0.45	0.095	0.059	1.31
Embankment (existing Impoundment)	5×10^{-4}	0.43	0.065	0.075	1.89
Embankment Drain	3.8×10^{-2}	0.42	0.005	4.93	2.19
Foundation	2.0×10^{-5}	0.41	0.095	0.019	1.31

Table 3

Tailings Water Seepage Estimates

Estimate	Inflow		Outflow		
	Precipitation	Process Water	Evaporation	Runoff	Seepage
Water balance during operation*	6,300	3,000	23,400	0	6,200
Water balance after closure**	7,200	0	6,800	40	330
HELP3 Model	7,000	0	6,600	200	190
Hydrologic model prior to closure***	6,700	21,000	26,800	0	4,400
Hydrologic model after closure***	6,700	0	6,400	0	220

* "Mass Balance Report", Shepherd Miller Inc., 1995

** "Acidification Potential of the Kennecott Tailings," Schafer and Associates, and Shepherd Miller, Inc., 1995 (See Appendix A) and "Tailings Water Model North Expansion", Schafer and Associates, 1997 (See Appendix B)

*** "Tailings Water Model North Expansion", Schafer and Associates, 1997 (See Appendix B)

+ Does not include seepage losses to ground water independently estimated at 826 gpm during operation.

+ Estimated for the operational period.

Table 4

Post Closure Sampling Frequency for Monitoring Wells

Sample Type	Sampling Point	Frequency		
		0 - 5 years	5 - 10 years	10 - 30 years*
NET449D	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET531B	Ground Water	Semi-Annual	Annual	Not Sampled
NET532A	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET532B	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET536A	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET536B	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET536C	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET604A	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET604A	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET646A	Ground Water	Semi-Annual	Annual	Not Sampled
NET646B	Ground Water	Semi-Annual	Annual	Not Sampled
NET1380A	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1380B	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1381A	Ground Water	Semi-Annual	Annual	Not Sampled
NET1381B	Ground Water	Semi-Annual	Annual	Not Sampled
NET1382A	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1382B	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1382C	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1383A	Ground Water	Semi-Annual	Annual	Not Sampled
NET1383B	Ground Water	Semi-Annual	Annual	Not Sampled
NET1384A	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1384A	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1385A	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1385B	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1386A	Ground Water	Semi-Annual	Annual	Not Sampled
NET1386B	Ground Water	Semi-Annual	Annual	Not Sampled
NET1387	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1393A	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1393B	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1492	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1493	Ground Water	Semi-Annual	Annual	Every Fifth Year
NET1494	Ground Water	Semi-Annual	Annual	Every Fifth Year

* These are anticipated frequencies, the actual frequency will be based on the results of a review conducted 10 years after closure.

Table 5

List of Analytes

Parameter	Ground Water Wells	Surface Water Samples	Tailings Wells	Lysimeters
FIELD				
pH	x	x	x	x
Temperature	x	x	x	x
Conductance	x	x	x	x
Depth to Water	x	x	x	
LABORATORY				
TDS	x	x	x	
TSS	x	x	x	
Gross-Alpha	x			
Gross-Beta	x			
Radium 226	x			
Radium 228	x			
Uranium	x			
Chloride (Cl^-)	x	x	x	x
Fluoride (F^-)	x	x	x	x
Sulfate ($SO_4^=$)	x	x	x	x
Calcium (Ca)	x			
Magnesium (Mg)	x			
Potassium (K)	x			
Sodium (Na)	x			
Alkalinity (ALK)	x			
Arsenic (As)	x	x	x	x
Barium (Ba)	x			
Cadmium (Cd)	x	x	x	x
Chromium (Cr)	x			
Copper (Cu)	x	x	x	x
Lead (Pb)	x			
Selenium (Se)	x	x	x	x
Zinc (Zn)	x			

Note: Radio nuclides (Uranium, radium 226, Radium 228, Gross Alpha, and Beta Particle) will be analyzed for in only wells NET1386A, NET1386B, NET1393A and NET1393B.

Table 6

Analytical Methods

Parameter	Analytical Method	Target Detection Limit
FIELD		
pH	150.1	N/A
Temperature	170.1	N/A
Conductance	2510B	10 umho/cm
Depth to Water	N/A	0.01 ft
LABORATORY		
TDS	160.1	10 mg/l
TSS	160.2	3 mg/l
Gross-Alpha	7110C	1 pCi/L
Gross-Beta	7110B	Dependent on TDS
Radium 226	903	2 pCi/L
Radium 228	904	1 pCi/L
Uranium	200.8	0.005 mg/l
Chloride (Cl^-)	325.2	5. mg/l
Fluoride (F^-)	4500F-C/300.0	0.2 mg/l
Sulfate ($SO_4^=$)	375.3, 375.4, 9036	5. mg/l
Calcium (Ca)	200.7	1 mg/l
Magnesium (Mg)	200.7, 242.1	1 mg/l
Potassium (K)	258.1, 200.7	0.1 mg/l
Sodium (Na)	200.7	1 mg/l
Alkalinity (ALK)	2320B	10 mg/l
Arsenic (As)	200.8, 200.9, 200.7	0.005 mg/l
Barium (Ba)	200.7, 200.8, 200.9	0.01 mg/l
Cadmium (Cd)	200.7, 200.8, 200.9	0.002 mg/l
Chromium (Cr)	218.1, 200.7, 200.8, 200.9	0.01 mg/l
Copper (Cu)	200.7, 200.8	0.02 mg/l
Lead (Pb)	239.1, 200.8, 200.9, 200.7	0.005 mg/l
Selenium (Se)	200.7, 200.8, 200.9	0.003 mg/l
Zinc (Zn)	289.1, 289.2, 200.7, 200.8, 200.9	0.01 mg/l

Table 7

Post Closure Monitoring Frequency for Tailings Seeps and Surface Water Sites

Sampling Point	Sample Type	Frequency
SURFACE WATER		
CLC452	Seepage and surface water	Quarterly
UPD007	Seepage and surface water	Quarterly
TAILINGS SEEPS		
TLS1427	Tailings seepage	Every Fifth Year
TLS1430	Tailings seepage	Every Fifth Year
TLS1434	Tailings seepage	Every Fifth Year

Table 8

Post Closure Monitoring Frequency for Tailings Wells and Lysimeters

Sampling Point	Sample Type	Frequency
WELLS		
TLT449C	Tailings Water	Annual
TLT887	Tailings Water	Annual
TLT2452	Tailings Water	Annual
TAILINGS LYSIMETERS		
TLL4100	Interstitial tailings water	Every Fifth Year
TLL4101	Interstitial tailings water	Every Fifth Year
TLL4102	Interstitial tailings water	Every Fifth Year
TLL4103	Interstitial tailings water	Every Fifth Year
TLL4131	Interstitial tailings water	Every Fifth Year
TLL4132	Interstitial tailings water	Every Fifth Year